Earth Radiation Budget Experiment (ERBE) Earth Radiant Fluxes and Albedo for Month (Scanner) (S-9)/Earth Radiant Fluxes and Albedo for Month (Nonscanner) (S-10) Langley ASDC Data Set Document

Summary:

This document describes the Earth flux and albedo data products for scanner (S-9) and nonscanner (S-10) and provides the user with the necessary information to use the Earth Radiation Budget Experiment (ERBE) data for scientific research studies.

The S-9 contains inverted daily, monthly hourly, and monthly averages of shortwave (SWF) and longwave (LWF) radiant fluxes at the top-of-atmosphere (TOA) for ERBE scanner data for one month. The S-10 contains the same information for the ERBE nonscanner data. One S-9 and four S-10 data sets are produced for each satellite that is operational during the month. If more than one satellite is operational during the month, a S-9 and a set of S-10's containing the combined multiple satellite data will be produced.

The four nonscanner (S-10) data sets produced are numerical filter (NF) medium field-of-view (MFOV), NF wide field-of-view (WFOV), shape factor (SF) MFOV, and SF WFOV.

There are two types of data records found on S-9 and S-10 for each region processed. The first record is a fixed length record containing averaged data. The second is a variable length record containing individual hour box estimates.

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1. Data Set Overview:

Data Set Identification:

ERBE_S9_NAT:	Earth Radiation Budget Experiment (ERBE) S-9 Scanner Radiant Flux and Albedo in Native (NAT) Format (ERBE_S9_NAT)
ERBE_S10_MFOV_NF_NAT:	Earth Radiation Budget Experiment (ERBE) S-10 Nonscanner, Medium Field of View (MFOV) Numerical Filter (NF) Radiant Flux and Albedo in Native (NAT) Format (ERBE_S10_MFOV_NF_NAT)
ERBE_S10_MFOV_SF_NAT:	Earth Radiation Budget Experiment (ERBE) S-10 Nonscanner, Medium Field of View (MFOV) Shape Factor (SF) Radiant Flux and Albedo in Native (NAT) Format (ERBE_S10_MFOV_SF_NAT)
ERBE_S10_WFOV_NF_NAT:	Earth Radiation Budget Experiment (ERBE) S-10 Nonscanner, Wide Field of View (WFOV) Numerical Filter (NF) Radiant Flux and Albedo in Native (NAT) Format (ERBE_S10_WFOV_NF_NAT)
ERBE_S10_WFOV_SF_NAT:	Earth Radiation Budget Experiment (ERBE) S-10 Nonscanner, Wide Field of View (WFOV) Shape Factor (SF) Radiant Flux and Albedo in Native (NAT) Format (ERBE_S10_WFOV_SF_NAT)

Data Set Introduction:

The S-9 contains regional and daily monthly averages as well as the actual individual hour box data which are the input to the Monthly Time/Space Averaging Subsystem for the scanner. The S-10 contains the same data for the nonscanner.

Objective/Purpose:

The objectives of ERBE are:

1. To determine, for a minimum of 1 year, the monthly average radiation budget on regional, zonal, and global scales.
2. To determine the equator-to-pole energy transport gradient.
3. To determine the average diurnal variation of the radiation budget on a regional and monthly scale.

Summary of Parameters:

The S-9 and S-10 contain regional and daily monthly averages as well as the actual individual hour box data which are the input to the Monthly Time/Space Averaging Subsystem.

The S-9 contains 2.5-degree resolution data from the scanner instrument and is available as a combination of all operational spacecraft (ERBS, NOAA-9, and NOAA-10). Single satellite data will soon be available. There may be three to eight S-9 files per month. The S-9 consists of two records for each region processed. The first record is of fixed length and contains the averaged data. The second record is of variable length and contains the hour box data. The data values are represented in scaled 16-bit integers. The scanner data for each region observed during a month are collected into a 32 X 25 matrix representing days and hours of the month; monthly (day), monthly (hour), daily, and monthly hourly averages are determined for each region. The values contained for each region are:

- Geographic scene type and scene fraction histogram
- Monthly mean shortwave and longwave flux
- Monthly mean clear-sky shortwave and longwave flux
- Monthly mean albedo
- Monthly mean net flux
- Monthly mean clear-sky albedo
- Monthly mean clear-sky net flux
- Monthly total integrated solar incidence
- Distance-corrected solar constant for the day
- Statistics such as minima, maxima, standard deviation, number of days with at least one estimate, sum, and sum squared of actual estimates

The S-10 contains numerical filter data of 5-degree resolution and shape factor of 10-degree resolution from the nonscanner instrument. It is available as a combinations of all operational spacecraft (ERBS, NOAA-9, and NOAA-10) for wide field-of-view (WFOV). For medium field-of-view (MFOV), the S-10 product is available as a combination of the ERBS and NOAA-9 spacecraft. Single satellite data will soon be available. Four S-10 files per month may be produced; one for MFOV numerical filter, MFOV shape factor, WFOV numerical filter, and WFOV shape factor. The S-10 contains two records for each region processed. The first record is of fixed length and contains the monthly averages; the second record is of variable length and contains the hour box data. The data values are represented in scaled 16-bit integers. The nonscanner data for each region observed during a month are collected into a 32 X 25 matrix representing days and hours of the month; monthly (day), monthly (hour), daily, and monthly hourly averages are determined for each region. The values contained for each region are as follows:

- Geographic scene type

- Monthly mean shortwave flux
- Monthly mean longwave flux
- Monthly mean albedo
- Monthly mean net flux
- Monthly total integrated solar incidence
- Distance-corrected solar constant for the day
- Statistics such as minima, maxima, standard deviation, number of days with at least one estimate, sum, and sum squared of actual estimates.

Discussion:

The goal of ERBE is to produce monthly averages of longwave and shortwave radiation parameters on the Earth at regional to global scales. Preflight mission analysis lead to a three-spacecraft system to provide the geographic and temporal sampling required to meet this goal. Three nearly identical sets of instruments were built and launched on three separate spacecraft. These instruments differ principally in the spacecraft interface electronics and in the field-of-view limiters for the nonscanner instruments required because of differences in the spacecraft orbit altitudes.

The ERBS spacecraft was launched by Space Shuttle Challenger in October 1984 and was the first spacecraft to carry ERBE instruments into orbit. The ERBS was designed and built by Ball Aerospace Systems under contract to NASA Goddard Space Flight Center (GSFC), and ERBS was the first spacecraft dedicated to NASA science experiments to be launched by the Space Shuttle. The ERBS carries the Stratospheric Aerosol and Gas Experiment (SAGE II) in addition to the ERBE instruments. The Payload Operation and Control Center (POCC) at GSFC directs operations of the ERBS spacecraft and the ERBE and SAGE II instruments, employing both ground stations and the Tracking and Data Relay Satellite System (TDRSS) network. Spacecraft and instrument telemetry data are received at GSFC where the data are processed by the Information Processing Division that provides ERBE and SAGE II experiment data to the NASA Langley Research Center (LaRC).

The second and third spacecraft launched with ERBE instruments are Television Infrared Radiometer Orbiting Satellite (TIROS) N-class spacecraft, which are part of the NOAA operational meteorological satellite series. The NOAA-9 and NOAA-10 spacecraft were launched in December 1984 and September 1986, respectively. The NOAA spacecraft include other instruments, such as the Advanced Very High Resolution Radiometer (AVHRR) and the High-Resolution Infrared Radiometer Sounder (HIRS), which provide NOAA with data for near-real-time weather forecasting. Both spacecraft are in nearly sun-synchronous orbits. The equator-crossing times (at launch) of the orbital nodes for the NOAA-9 and NOAA-10 orbits were 1420 UT (ascending) and 1930 UT (descending), respectively, where UT denotes universal time. The Satellite Operations and Control Center (SOCC) at the National Environmental Satellite and Data Information Service (NESDIS) operates the NOAA spacecraft. NOAA also provides decommutation processing of the telemetry data and generates ERBE data for LaRC.

NASA tracks the ERBS spacecraft, and the North American Aerospace Defense Command (NORAD) tracks the NOAA spacecraft. The tracking data are provided to GSFC where orbit ephemeris data are calculated for all three spacecraft and provided to LaRC.

Related Data Sets:

SRB_Daily:	Surface Radiation Budget Daily Averages
SRB_Monthly:	Surface Radiation Budget Monthly Averages

2. Investigator(s):

Investigator(s) Name and Title:

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Title of Investigation:

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3. Theory of Measurements:

The theory behind the measurements made to collect the ERBE data is non-trivial and well beyond the scope of this document. However, interested readers are referred to the following publications: Suttles (Reference 14) and Smith (Reference 23).

4. Equipment:

Sensor/Instrument Description:

Collection Environment:

All three sets of ERBE instruments were designed to collect data for one year but had a goal of two years. The nonscanner instruments continue to collect data for ERBS; however, the nonscanner instruments on-board NOAA-9 and NOAA-10 have been deactivated. Table 1 describes the nominal orbit parameters for each satellite at launch.

Table 1. Nominal Orbit Parameters for Each Satellite at Launch

Nominal Orbit Parameter	ERBS	NOAA-9	NOAA-10
Launch Date	October 5, 1984	December 12, 1984	September 17, 1986
Planned Duration	1 Year	1 Year	1 Year
Actual Duration Scanner	5-1/2 years (February 28, 1990)	3 years (January 20, 1987)	2-1/2 years (May 22, 1989)
Actual Duration Nonscanner	Operating	Over 12 years, deactivated April 3, 1997	Over 8 years, deactivated December, 1994
Orbit	Precessing	Sun-synchronous	Sun-synchronous
Semi-major Axis	6988 km	7248 km	7211 km
Mean Altitude	610 km	872 km	833 km
Inclination	57 deg	98 deg	98 deg
Nodal Period	98 minutes	102.08 minutes	101.2 minutes
Equator Crossing Time (at launch)	Variable	1430 Local Mean Solar Time, ascending	0730 Local Mean Solar Time, descending

Source/Platform:

The ERBE instruments are on the ERBS, NOAA-9, and NOAA-10 satellites.

Source/Platform Mission Objectives:

ERBS was the first spacecraft dedicated to NASA science experiments to be launched by the Space Shuttle. ERBS carries SAGE II instruments in addition to the ERBE instruments. The NOAA spacecraft include other instruments, such as the Advanced Very High Resolution Radiometer (AVHRR) and the High-Resolution Infrared Radiometer Sounder (HIRS), which provide NOAA with data for near-real-time weather forecasting.

Key Variables:

A complete list of the measured parameters is found in Table 2.

Table 2. ERBS, NOAA-9, and NOAA-10 ERBE Detector Characteristics

	CHANNEL	WAVELENGTH LIMITS (microns)	MEASUREMENT
Nonscanner Fixed Wide field of view	1	0.2-50.0	Total Radiance
	2	0.2 - 5.0	Shortwave Reflected
Nonscanner Fixed Medium field-	3	0.2 - 50.0	Total Radiance

of-view	4	0.2 - 5.0	Shortwave Reflected
Fixed Solar Monitor	5	0.2 - 50.0	Total Irradiance
Scanner Narrow field-of-view	1	0.2 - 50.0	Total Radiance
	2	0.2 - 45.0	Shortwave Reflected
	3	5.0 - 50.0	Longwave Emitted

Principles of Operation:

ERBE is a multisatellite system designed to measure the Earth's radiation budget. The ERBE instruments fly on a mid-inclination NASA satellite, (ERBS), and two sun-synchronous NOAA satellites, (NOAA-9 and NOAA-10). Each satellite carries both a scanner and a nonscanner instrument package with characteristics listed in Table 2.

The scanner package contains three radiometric detectors each of which consists of an f/1.84 Cassegrain telescope. All are located within a single, rotating scan-head which, when operating in the cross track azimuth position, scans the Earth perpendicular to the satellite ground track from horizon to horizon. The scan-head can also be rotated in azimuth at a slow rate (0.9 degrees/second NOAA, 0.675 degrees/second ERBS). Each detector samples 74 measurements per scan. The total detector has no filter and so absorbs all wavelengths. The shortwave detector has a Suprasil-W1 filter which transmits only shortwave radiation. The longwave detector has a multilayer filter on a diamond substrate to reject shortwave and accept longwave radiation. To enhance the spectral flatness of the detectors, each thermistor chip is coated with a thin layer of black paint.

The nonscanner instrument package contains four Earth-viewing channels and a solar monitor. The Earth-viewing channels have two spatial resolutions: a horizon-to-horizon view of the Earth, and a field-of-view limited to about 1000 km in diameter. The former are called the wide field-of-view (WFOV) and the latter the medium field-of-view (MFOV) channels. For each of the two fields of view, there is a total spectral channel which is sensitive to all wavelengths and a shortwave channel which uses a high purity, fused silica filter dome to transmit only the shortwave radiation from 0.2 to 5 microns. The solar monitor is a direct descendant of the Solar Maximum Mission's Active Cavity Radiometer Irradiance Monitor detector. Because of the concern for spectral flatness and high accuracy, all five of the channels on the nonscanner package are active cavity radiometers.

Sensor/Instrument Measurement Geometry:

The nonscanner elevation beams can be rotated to any of three positions: launch/stow/internal calibration position (180 degrees), solar calibration position (78 degrees), and Earth-viewing (nadir) position (0 degrees). The WFOV detectors view the Earth from limb-to-limb (plus a small ring of space). The MFOV detectors are designed to include approximately an Earth view of 10 geocentric degrees within the unencumbered field of view (FOV).

The scanner can rotate in azimuth between 0 degrees and 180 degrees with an accuracy of 0.075 degrees. The normal scan mode is cross-track. The effective FOV of the scanner is 3 degrees.

Manufacturer of Sensor/Instrument:

The ERBE instruments were developed by TRW, Inc.

Calibration:

Specifications:

Not obtainable.

Tolerance:

The tolerance is 1 percent for the total channel and 2 percent for the shortwave channel.

Frequency of Calibration:

For the scanner instruments, in-flight calibrations were accomplished every scan, as well as on a bi-weekly basis. In-flight calibrations of the nonscanners were normally performed on a bi-weekly basis.

Other Calibration Information:

The ERBE instruments were developed by TRW, Inc. Laboratory calibrations of the ERBE nonscanner and solar monitor instruments were completed in the TRW calibration facility at Redondo Beach, California in 1984. The fundamental standards used for the ERBE instruments were the International Pressure and Temperature Standard of 1968 (IPTS-68) and the World Radiation Reference (WRR). The TRW master reference blackbody (MRBB) was calibrated using these, and the MRBB was subsequently used to transfer the calibrations to the internal blackbody (IBB) and to the shortwave channels via an integrating sphere. The results of the calibrations were reported in detail in TRW calibration documents.

In-flight calibrations are performed in order to maintain the accuracy of radiometric measurements by accounting for internal instrument component parametric changes brought about by the spacecraft's environmental variables. In-flight calibrations of the nonscanners were normally performed on a bi-weekly basis. These included internal calibrations, space looks, and solar calibrations. Internal calibrations consist of cycling of IBB temperatures (total sensors) and shortwave internal calibration source (SWICS) voltages. Space looks consist of observations of "cold" space, both before and after solar calibrations. Solar calibrations consist of measurements made while the solar disc is within the instrument's FOV.

On days when internal calibrations are performed, shortwave offsets are independently determined in four ways:

1. The preferred offsets are determined by using the aggregate of all earth-viewing data taken when the solar zenith angle is greater than 123 degrees, and assuming that the shortwave radiance is zero. Because of the solar zenith angle requirement, it is not always possible to use this method.
2. The second choice offsets are determined by using the data acquired during the internal calibration period, with the SWICS-off. Again it is presumed that the shortwave radiance is zero.
3. The third choice offsets are determined using data acquired during the so-called "B-soak" period which occurs before every internal calibration sequence is begun. During this period, all of the sensors are exposed to their respective calibration sources, but all power to the sources is off.
4. The fourth choice offsets are determined from the (approximately 30) samples of "cold" space which occur between the solar disk observation and the re-capture of the earth disk.

In cases where the first option is not viable, the second option is used, along with a linearly-fitted delta based upon the historical differences between method 1 and method 2. The offsets determined using options 3 and 4 have never been used in production processing.

5. Data Acquisition Methods:

The ERBE nonscanner instrument consists of four Earth-viewing detectors and one solar monitor detector located on the head assembly. The four Earth-viewing detectors are unchopped active cavity radiometers (ACR), whereas the solar monitor is an unfiltered chopped ACR designed to measure direct solar radiation for calibrating the Earth-viewing detectors. Two of these detectors have wide field-of-view (WFOV) apertures allowing the detectors to view the entire disk of the Earth; the other two detectors have medium field-of-view (MFOV) apertures allowing the detectors to view an area about 1000 km in diameter. Two of the Earth-viewing detectors, one WFOV and one MFOV, and the solar monitor detector measure total radiation, whereas the other two Earth-viewing detectors measure shortwave radiation. The total radiation detectors are unfiltered, and the shortwave spectral bands are achieved by use of fused silica dome filters placed over the detectors.

The nonscanner instrument microprocessor processes and executes ground-commanded and stored commands to direct and control the instrument operations. The instrument can operate in several modes so that radiation measurements can be made over a wide range of operational conditions. The instrument can operate at azimuth angles between 0 and 180 degrees, and at fixed elevation beam positions of 0(nadir), 78 (solar ports), and 180 (stow or internal calibration position) degrees. Normal Earth-viewing operation is at the nadir elevation position and at an azimuth position of 180 degrees for NOAA-10, 170 degrees for NOAA-9, and 0 degrees for ERBS. The ERBE nonscanner instrument output consists of a complete cycle of radiometric and housekeeping measurements every 16 seconds. There are 20 radiometric measurements every 16 seconds, while the frequency of housekeeping measurements is either 1, 2, or 4 measurements per 16 seconds, depending on the type of measurement.

Telemetry data from the ERBE instruments on the NOAA-9 and NOAA-10 spacecraft are transmitted to Control and Data Acquisition (CDA) ground stations at Gilmore Creek, Alaska, and Wallops Island, Virginia that relay the data through a geostationary communications satellite to the SOCC at NESDIS in Suitland, Maryland, NOAA provides decommutation processing of the telemetry data and provides the data to LaRC. During portions of the ERBE mission, telemetry data from the NOAA spacecraft were transmitted to GSFC for decommutation processing and delivery to LaRC. Telemetry and tracking data from the ERBE instrument on ERBS are transmitted to the NASA ground terminal at White Sands, New Mexico through the Tracking and Data Relay Satellite System (TDRSS). The data are transmitted from the ground terminal to the NASA communications center at GSFC, where the data are processed by the Information Processing Division (IPD) that provides ERBE data to LaRC.

6. Observations:

Data Notes:

Not obtainable.

Field Notes:

Not obtainable.

7. Data Description:

Spatial Characteristics:

Spatial Coverage:

The spatial coverage differs with the channel and the spacecraft, as described below.

WFOV Instruments: these two fixed detectors continuously view the earth disc (plus a small ring of space). The measurements are continuous over the entire globe for NOAA-9 and NOAA-10, and between 57 degrees north and south latitudes for ERBS which processes approximately 3.95 degrees west per day.

MFOV Instruments: these two fixed detectors continuously view an area about 1000 km in diameter (nominally, a 5 degree earth central angle at the top of the Earth atmosphere, TOA). The measurements are continuous over the entire globe for NOAA-9 and NOAA-10, and between 57 degrees north and south latitude for ERBS.

Scanner Instruments: these three scanning instruments continuously view small areas over the entire Earth. The cross-track scan FOV is approximately 40 km at nadir, and there is a 35FOV overlap at nadir for ERBS between scans.

ERBE scanner instruments on board the NOAA-9 and NOAA-10 satellites provide global coverage, while the ERBE scanner instrument onboard ERBS provides coverage between 67.5 degrees north and south latitude.

Spatial Coverage Map:

Though a map is not available, the limits of coverage are discussed in the Spatial Coverage Section.

Spatial Resolution:

The spatial resolution differs with the four types of instruments and the two types of spacecraft (ERBS and NOAA). The WFOV instruments have 136 degree FOV on ERBS and 126 degree FOV on the NOAA satellites. The MFOV instruments have footprints of approximately 5 geocentric degree radius or 1000 km at the TOA. The scanner instruments have an instantaneous hexagonal FOV with an angular size of 3 X 4.5 degree, which is equivalent to a 31 X 47 km footprint at nadir for ERBS and 44 X 65 km for NOAA. The solar instrument has an unencumbered FOV which observes the entire solar disk.

The S-9 product contains data which have been averaged to a 2.5 grid scale. The S-10 contains data which have been averaged to 5.0 or 10.0 grid scale.

Projection:

Gridding is an equal-angle projection of 2.5 X 2.5 degree (NFOV, 10368 bins), 5.0 X 5.0 degree (MFOV, 2592 bins), and 10.0 X 10.0 degree (WFOV, 648 bins).

Grid Description:

Binning of the data is based on an equal-angle grid of 2.5 X 2.5 degree (NFOV, 10368 bins), 5.0 X 5.0 degree (MFOV, 2592 bins), and 10.0 X 10.0 degree (WFOV, 648 bins). In each resolution, the bin number 1 is found at 90 degree N, 0 degree W with the bin number increasing in an easterly direction.

The layout of a 2.5 system is given; the 5.0 and 10.0 systems are designed similarly. In this grid system, L = longitude and λ = latitude is replaced with colatitude, where $\lambda_{CO} = 90 - \lambda$ so that $0° <= \lambda_{co} <= 180°$

The following list shows the number of regions for each resolution:

Resolution	Total No. Regions
2.5	10,368
5.0	2,592
10.0	648

Temporal Characteristics:

Temporal Coverage:

Instruments on the three satellites (ERBS, NOAA-9, and NOAA-10) began acquiring Earth viewing data in November 1984, February 1985, and October 1986, respectively. All of the scanner instruments outlived their life expectancy of one year. The NOAA-9 scanner ceased operations on January 20, 1987 and the NOAA-10 scanner on May 22, 1989. The ERBS scanner ceased operations on February 28, 1990. All of the Earth-viewing nonscanner instruments collect measurements continuously except during calibrations. The solar instrument collects about 20 minutes of usable data during bi-weekly solar calibration periods.

Temporal Coverage Map:

Table 3 shows the archival status of the S-9 and S-10 product. Note that MFOV data were not processed for the NOAA-10 satellite. Single satellite data will soon be archived. For updated information on currently archived data please refer to the Langley ASDC Information Management System (IMS).

Table 3: Archival Status of S-9/S-10 Products from 1984 to 1990

November 1984 - January 1985	ERBS
February 1985 - October 1986	ERBS/NOAA-9
November 1986 - January 1987	ERBS/NOAA-9/NOAA-10 *
February 1987 - May 1989	ERBS/NOAA-10*
June 1989 - February 1990	ERBS
** MFOV data from NOAA-10 are not archived.*	

Temporal Resolution:

Data records for the Level 2 products are instantaneous measurements and estimates. Gridded data (the S-9 and S-10 products) are daily, monthly hour (hourly averages for a month), monthly day (daily averages for a month), and hourly. Individual hour box estimates are also in S-9 and S-10.

Data Characteristics:

Parameter/Variable: (S-10)

There are two data records for each region processed. The data records are written as 16-bit words. Some values are too large to be placed in one 16-bit word and, therefore, occupy two 16-bit words. The method of restoring the values in these words is discussed in the Variable Description/Definition Section of this document.

The first record for a region is of fixed length and contains the averaged data. There are 1860 words in this record for the S-9 and 990 words for the S-10. The second record is of variable length and contains the "actual" hour box data passed from the Inversion Subsystem (Reference 8) through the Daily Data Base Subsystem (Reference 6). The length of this record in words can be calculated by multiplying the number of hour boxes (1846th word of record 1 for the scanner and the 978th word of record 1 for the nonscanner) by the number of values passed per hour box. The number of values is 32 for the scanner and 38 for the nonscanner.

Detailed record structures of the S-9 and S-10 output products are shown in Table 5 and pictorial summaries of these products are shown in Table 6 and Table 7. The scale factors given in Tables 4 and 5 are typical values. The actual values used to scale the data are recorded in the first record as discussed in the Data Format Section of this document. These are the values that should be used to scale the integer data and not the values in Tables 4 and 5.

The S-9 will typically occupy more than one file. A logical division based on latitude band processing allows for any file to have data for all the regions appearing in any latitude band. The number of latitude bands put on any one file is dependent upon the number of hours seen within the regions present. A summary, a sample of which is shown in Figure 2, tells which regions are grouped on any file.

Table 4: Detailed Record Structure for Scanner Output Tape (S-9)

Temporal Scale	Record Index	Parameter Name	Units	Scale Factor		No. of Data Values in Record	Cumulative Total Bits
				Name	Value		
Monthly (day)	1	Region number	---	SCALE1(1)	1	-	16
	2	Geographic scene type	---	SCALE1(2)	100	1	32

	3-6	Scene fraction histogram(4)	---	SCALE1(3)	100	4	96
	7	$\overline{M}_{SW}$	Wm^{-2}	SCALE1(4)	10	1	112
	8	$M_{MIN_{SW}}$	Wm^{-2}	SCALE1(5)	10	1	128
	9	$M_{MAX_{SW}}$	Wm^{-2}	SCALE1(6)	10	1	144
	10	σ_{SW}	Wm^{-2}	SCALE1(7)	100	1	160
	11	N_{SW}	---	SCALE1(8)	1	1	176
	12	$\overline{M}_{LW}$	Wm^{-2}	SCALE1(9)	10	1	192
	13	$M_{MIN_{LW}}$	Wm^{-2}	SCALE1(10)	10	1	208
	14	$M_{MAX_{LW}}$	Wm^{-2}	SCALE1(11)	10	1	224
	15	σ_{LW}	Wm^{-2}	SCALE1(12)	100	1	240
	16	N_{LW}	---	SCALE1(13)	1	1	256
	17	$\overline{\alpha}$	---	SCALE1(14)	10000	1	272
	18	$\overline{M}_{NET}$	Wm^{-2}	SCALE1(15)	100	1	288
	19	TSOLRD(1)	Wm^{-2}	SCALE1(16)	1	1	304
	20	TSOLRD(2)	Wm^{-2}	SCALE1(17)	10	1	320
	21	$\overline{M}_{SW}{}_{CS}$	Wm^{-2}	SCALE1(4)	10	1	336
	22	$M_{MIN_{CS}}$	Wm^{-2}	SCALE1(5)	10	1	352
	23	$M_{MAX_{SW_{CS}}}$	Wm^{-2}	SCALE1(6)	10	1	368
	24	$\sigma_{SW}{}_{CS}$	Wm^{-2}	SCALE1(7)	100	1	384
	25	$N_{SW_{CS}}$	---	SCALE1(8)	1	1	400
	26	$\overline{M}_{LW}{}_{CS}$	Wm^{-2}	SCALE1(9)	10	1	416
	27	$M_{MIN_{LW_{CS}}}$	Wm^{-2}	SCALE1(10)	10	1	432
	28	$M_{MAX_{LW_{CS}}}$	Wm^{-2}	SCALE1(11)	10	1	448
	29	$\sigma_{LW}{}_{CS}$	Wm^{-2}	SCALE1(12)	100	1	464
	30	$N_{LW_{CS}}$	---	SCALE1(13)	1	1	480
	31	$\overline{\alpha}{}_{CS}$	---	SCALE1(14)	10000	1	496
Monthly (hour)	32	$\overline{M}_{NET}{}_{CS}$	Wm^{-2}	SCALE1(15)	100	1	512
	33	$TSOLRD_{CS}(1)$	$W\text{-}hm^{-2}$	SCALE1(16)	1	1	528
	34	$TSOLRD_{CS}(2)$	$W\text{-}hm^{-2}$	SCALE1(17)	10	1	544
	35	$\overline{M}_{SW}$	Wm^{-2}	SCALE1(18)	10	1	560
	36	$M_{MIN_{SW}}$	Wm^{-2}	SCALE1(19)	10	1	576
	37	$M_{MAX_{SW}}$	Wm^{-2}	SCALE1(20)	10	1	592
	38	σ_{SW}	Wm^{-2}	SCALE1(21)	100	1	608
	39	N_{SW}	---	SCALE1(22)	1	1	624
	40	$\overline{M}_{LW}$	Wm^{-2}	SCALE1(23)	10	1	640
	41	$M_{MIN_{LW}}$	Wm^{-2}	SCALE1(24)	10	1	656
	42	$M_{MAX_{LW}}$	Wm^{-2}	SCALE1(25)	10	1	672
	43	σ_{LW}	Wm^{-2}	SCALE1(26)	100	1	688
	44	N_{LW}	---	SCALE1(27)	1	1	704
	45	$\overline{\alpha}$	---	SCALE1(28)	10000	1	720
	46	$\overline{M}_{NET}$	Wm^{-2}	SCALE1(29)	100	1	736
	47	TSOLRH(1)	$W\text{-}hm^{-2}$	SCALE1(30)	1	1	752
	48	TSOLRH(2)	$W\text{-}hm^{-2}$	SCALE1(31)	10	1	768
	49	$\overline{M}_{SW}{}_{CS}$	Wm^{-2}	SCALE1(18)	10	1	784
	50	$M_{MIN_{SW_{CS}}}$	Wm^{-2}	SCALE1(19)	10	1	800
	51	$M_{MAX_{SW_{CS}}}$	Wm^{-2}	SCALE1(20)	10	1	816
	52	$\sigma_{SW}{}_{CS}$	Wm^{-2}	SCALE1(21)	100	1	832
	53	$N_{SW_{CS}}$	---	SCALE1(22)	1	1	848
	54		Wm^{-2}	SCALE1(23)	10	1	864

		$\overline{M}_{LW}$: CS					

	55	$M_{MIN_{LW_{cs}}}$	Wm^{-2}	SCALE1(24)	10	1	880
	56	$M_{MAX_{LW_{cs}}}$	Wm^{-2}	SCALE1(25)	10	1	896
	57	σ_{LW} CS	Wm^{-2}	SCALE1(26)	100	1	912
	58	$N_{LW_{CS}}$	---	SCALE1(27)	1	1	928
	59	$\bar{\alpha}$ CS	---	SCALE1(28)	10000	1	944
	60	$\bar{M}_{NET}$ CS	Wm^{-2}	SCALE1(29)	100	1	960
	61	$TSOLRD_{CS}(1)$	W-hm^{-2}	SCALE1(30)	1	1	976
	62	$TSOLRD_{CS}(2)$	W-hm^{-2}	SCALE1(31)	10	1	992
Daily	63 thru 837	DEO	Wm^{-2}	SCALE1(32)	10	25x31	
		$\bar{M}_{SW}$	Wm^{-2}	SCALE1(33)	10		
		$M_{MIN_{SW}}$	Wm^{-2}	SCALE1(34)	10-		
		$M_{MAX_{SW}}$	Wm^{-2}	SCALE1(35)	10		
		σ_{SW}	Wm^{-2}	SCALE1(36)	100		
		N_{SW}	---	SCALE1(37)	1		
		$\bar{M}_{LW}$	Wm^{-2}	SCALE1(38)	10		
		$M_{MIN_{LW}}$	Wm^{-2}	SCALE1(39)	10		
		$M_{MAX_{LW}}$	Wm^{-2}	SCALE1(40)	10		
		σ_{LW}	Wm^{-2}	SCALE1(41)	100		
		N_{LW}	---	SCALE1(42)	1		
		$\bar{\alpha}$	---	SCALE1(43)	10000		
		SOLARD(1)	W-hm^{-2}	SCALE1(44)	1		
		SOLARD(2)	W-hm^{-2}	SCALE1(45)	10		
		$\bar{M}_{SW}$ CS	Wm^{-2}	SCALE1(33)	10		
		$M_{MIN_{SW_{cs}}}$	Wm^{-2}	SCALE1(34)	10		
		$M_{MAX_{SW_{cs}}}$	Wm^{-2}	SCALE1(35)	10		
		σ_{SW} CS	Wm^{-2}	SCALE1(36)	100		
		$N_{SW_{CS}}$	---	SCALE1(37)	1		
		$\bar{M}_{LW}$ CS	Wm^{-2}	SCALE1(38)	10		
		$M_{MIN_{LW_{cs}}}$	Wm^{-2}	SCALE1(39)	10		
		$M_{MAX_{LW_{cs}}}$	Wm^{-2}	SCALE1(40)	10		
		σ_{LW} CS	Wm^{-2}	SCALE1(41)	100		
		$N_{LW_{CS}}$	---	SCALE1(42)	1		
		$\bar{\alpha}$ CS	---	SCALE1(43)	10000		13392
Monthly Hourly	838 thru 1845	$\bar{M}_{SW}$	Wm^{-2}	SCALE1(46)	10	42x24	
		$M_{MIN_{SW}}$	Wm^{-2}	SCALE1(47)	10		
		$M_{MAX_{SW}}$	Wm^{-2}	SCALE1(48)	10		
		σ_{SW}	Wm^{-2}	SCALE1(49)	100		
		N_{SW}	---	SCALE1(50)	1		
		$SUM_{SW(1)}$	W-hm^{-2}	SCALE1(51)	1		
		$SUM_{SW}(2)$	W-hm^{-2}	SCALE1(52)	10		
		$SUM2_{SW(1)}$	W-hm^{-22}	SCALE1(53)	1		
		$SUM2_{SW(2)}$	W-hm^{-22}	SCALE1(54)	10		
		$\bar{M}_{LW}$	Wm^{-2}	SCALE1(55)	10		
		$M_{MIN_{LW}}$	Wm^{-2}	SCALE1(56)	10		
		$M_{MAX_{LW}}$	Wm^{-2}	SCALE1(57)	10		
		σ_{LW}	Wm^{-2}	SCALE1(58)	100		
		N_{LW}	---	SCALE1(59)	1		
		$SUM_{LW(1)}$	W-hm^{-2}	SCALE1(60)	1		
		$SUM_{LW}(2)$	W-hm^{-2}	SCALE1(61)	10		
		$SUM2_{LW(1)}$	W-hm^{-22}	SCALE1(62)	1		

		$SUM2_{LW(2)}$	W-hm^{-22}	SCALE1(63)	10		
		$\overline{\alpha}$:	---	SCALE1(64)	10000		
		SOLARH(1)	W-hm^{-2}	SCALE1(65)	1		
		SOLARH(2)	W-hm^{-2}	SCALE1(66)	10		
		$\overline{M}_{SW}$: CS	Wm^{-2}	SCALE1(46)	10		
		$M_{MIN_{SW_{cs}}}$	Wm^{-2}	SCALE1(47)	10		
		$M_{MAX_{SW_{cs}}}$	Wm^{-2}	SCALE1(48)	10		
		σ_{SW}: CS	Wm^{-2}	SCALE1(49)	100		
		N_{SWCS}	---	SCALE1(50)	1		
		$SUM_{SW(1)_{cs}}$	W-hm^{-2}	SCALE1(51)	1		
		$SUM_{SW_{cs}}(2)$	W-hm^{-2}	SCALE1(52)	10		
		$SUM2_{SW(1)_{cs}}$	W-hm^{-22}	SCALE1(53)	1		
		$SUM2_{SW(2)_{cs}}$	W-hm^{-22}	SCALE1(54)	10		
		$\overline{M}_{LW}$: CS	Wm^{-2}	SCALE1(55)	10		
		$M_{MIN_{LW_{cs}}}$	Wm^{-2}	SCALE1(56)	10		
		$M_{MAX_{LW_{cs}}}$	Wm^{-2}	SCALE1(57)	10		
		σ_{LW}: CS	Wm^{-2}	SCALE1(58)	100		
		$N_{LW_{cs}}$	---	SCALE1(59)	1		
		$SUM_{LW(1)_{cs}}$	W-hm^{-2}	SCALE1(60)	1		
		$SUM_{LW_{cs}}(2)$	W-hm^{-2}	SCALE1(61)	10		
		$SUM2_{LW(1)_{cs}}$	W-hm^{-22}	SCALE1(62)	1		
		$SUM2_{LW(2)_{cs}}$	W-hm^{-22}	SCALE1(63)	10		
		$\overline{\alpha}$: CS	---	SCALE1(64)	10000		
		$SOLARH(1)_{CS}$	W-hm^{-2}	SCALE1(65)	1		
		$SOLARH(2)_{CS}$	W-hm^{-2}	SCALE1(66)	10		29520
Monthly	1846	$N_{HR\text{-}DAY}$	---	SCALE1(67)	1	1	-
	1847 - 1860	Spares	-	-	-	14	29760
Hourly/ Day*	1	Hour box	---	SCALE2(1)	1	1	16
	2	Whole Julian date(1)	day	SCALE2(2)	1	1	32
	3	Whole Julian date(2)	day	SCALE2(3)	1	1	48
	4	Fractional Julian date	day	SCALE2(4)	10000	1	64
	5-8	Scene fraction(9)	---	SCALE2(5)	10000	1	128
	9-12	$\overline{\alpha}$: (4)	---	SCALE2(6)	10000	1	192
	13	$COS(ZEN)_{SUN}$	---	SCALE2(7)	10000	1	208
	14	Satellite zenith angle	degrees	SCALE2(8)	100	1	224
	15	Azimuth angle	degrees	SCALE2(9)	100	1	240
	16	SOLAR	Wm^{-2}	SCALE2(10)	10	1	256
	17	$\overline{M}_{SW}$:	Wm^{-2}	SCALE2(11)	10	1	272
	18	$M_{MIN_{SW}}$	Wm^{-2}	SCALE2(12)	10	1	288
	19	$M_{MAX_{SW}}$	Wm^{-2}	SCALE2(13)	10	1	304
	20	σ_{SW}:	Wm^{-2}	SCALE2(14)	100	1	320
	21	N_{SW}	---	SCALE2(15)	1	1	336
	22	$\overline{M}_{LW}$:	Wm^{-2}	SCALE2(16)	10	1	352
	23	$M_{MIN_{LW}}$	Wm^{-2}	SCALE2(17)	10	1	368
	24	$M_{MAX_{LW}}$	Wm^{-2}	SCALE2(18)	10	1	384
	25	σ_{LW}:	Wm^{-2}	SCALE2(19)	10	1	400

	26	N_{LW}	---	SCALE2(20)	1	1	416
	27	$M_{DIFF_{SW}}$	Wm^{-2}	SCALE2(21)	100	1	432
	28	$M_{DIFF_{LW}}$	Wm^{-2}	SCALE2(22)	100	1	448
	29	-	Wm^{-2}	SCALE2(23)	10000	1	464
	30	$\overline{M}_{LW_{CS}}$	Wm^{-2}	SCALE2(24)	10	1	480
	31	$\sigma_{LW_{CS}}$	Wm^{-2}	SCALE2(25)	100	1	496
	32	$N_{LW_{CS}}$	Wm^{-2}	SCALE2(26)	1	1	512*

* *Repeated $N_{HR\text{-}DAY}$ times*

Table 5: Detailed Record Structure for Nonscanner Output Tape (S-10)

Temporal Scale	Record Index	Parameter Name	Units	Scale Factor		No. of Data Values in Record	Cumulative Total Bits
				Name	Value		
-	1	Region number	---	SCALE1(1)	1	-	16
-	2	Geographic scene type	---	SCALE1(2)	100	-	32
-	3-11	Scene fraction histogram(9)	---	SCALE1(3)	100	-	176
Monthly (day)	12	$\overline{M}_{SW}$	Wm^{-2}	SCALE1(4)	10	1	192
	13	$M_{MIN_{SW}}$	Wm^{-2}	SCALE1(5)	10	1	208
	14	$M_{MAX_{SW}}$	Wm^{-2}	SCALE1(6)	10	1	224
	15	σ_{SW}	Wm^{-2}	SCALE1(7)	100	1	240
	16	N_{SW}	---	SCALE1(8)	1	1	256
	17	$\overline{M}_{LW}$	Wm^{-2}	SCALE1(9)	10	1	272
	18	$M_{MIN_{LW}}$	Wm^{-2}	SCALE1(10)	10	1	288
	19	$M_{MAX_{LW}}$	Wm^{-2}	SCALE1(11)	10	1	304
	20	σ_{LW}	Wm^{-2}	SCALE1(12)	100	1	320
	21	N_{LW}	---	SCALE1(13)	1	1	336
	22	$\overline{\alpha}$	---	SCALE1(14)	10000	1	352
	23	$\overline{M}_{NET}$	Wm^{-2}	SCALE1(15)	100	1	368
	24	TSOLRD(1)	Wm^{-2}	SCALE1(16)	1	1	384
	25	TSOLRD(2)	Wm^{-2}	SCALE1(17)	10	1	400
Monthly (hour)	26	$\overline{M}_{SW}$	Wm^{-2}	SCALE1(18)	10	1	416
	27	$M_{MIN_{SW}}$	Wm^{-2}	SCALE1(19)	10	1	432
	28	$M_{MAX_{SW}}$	Wm^{-2}	SCALE1(20)	10	1	448
	29	σ_{SW}	Wm^{-2}	SCALE1(21)	100	1	464
	30	N_{SW}	---	SCALE1(22)	1	1	480
	31	$\overline{M}_{LW}$	Wm^{-2}	SCALE1(23)	10	1	496
	32	$M_{MIN_{LW}}$	Wm^{-2}	SCALE1(24)	10	1	512
	33	$M_{MAX_{LW}}$	Wm^{-2}	SCALE1(25)	10	1	528
	34	σ_{LW}	Wm^{-2}	SCALE1(26)	100	1	544
	35	N_{LW}	---	SCALE1(27)	1	1	560
	36	$\overline{\alpha}$	---	SCALE1(28)	10000	1	576
	37	$\overline{M}_{NET}$	Wm^{-2}	SCALE1(29)	100	1	592
	38	TSOLRH(1)	$W\text{-}hm^{-2}$	SCALE1(30)	1	1	608
	39	TSOLRH(2)	$W\text{-}hm^{-2}$	SCALE1(31)	10	1	624
Daily	40 thru 473	DEO	Wm^{-2}	SCALE1(32)	10	14x31	
		$\overline{M}_{SW}$	Wm^{-2}	SCALE1(33)	10		

		$M_{MIN_{SW}}$	Wm^{-2}	SCALE1(34)	10-		
		$M_{MAX_{SW}}$	Wm^{-2}	SCALE1(35)	10		
		σ_{SW}:	Wm^{-2}	SCALE1(36)	100		
		N_{SW}	---	SCALE1(37)	1		
		$\overline{M}_{LW}$:	Wm^{-2}	SCALE1(38)	10		
		$M_{MIN_{LW}}$	Wm^{-2}	SCALE1(39)	10		
		$M_{MAX_{LW}}$	Wm^{-2}	SCALE1(40)	10		
		σ_{LW}:	Wm^{-2}	SCALE1(41)	100		
		N_{LW}	---	SCALE1(42)	1		
		$\overline{\alpha}$:	---	SCALE1(43)	10000		
		SOLARD(1)	$W\text{-}hm^{-2}$	SCALE1(44)	1		
		SOLARD(2)	$W\text{-}hm^{-2}$	SCALE1(45)	10		7568
Monthly Hourly	474 thru 977	$\overline{M}_{SW}$:	Wm^{-2}	SCALE1(46)	10	21x24	
		$M_{MIN_{SW}}$	Wm^{-2}	SCALE1(47)	10		
		$M_{MAX_{SW}}$	Wm^{-2}	SCALE1(48)	10		
		σ_{SW}:	Wm^{-2}	SCALE1(49)	100		
		N_{SW}	---	SCALE1(50)	1		
		$SUM_{SW(1)}$	$W\text{-}hm^{-2}$	SCALE1(51)	1		
		$SUM_{SW}(2)$	$W\text{-}hm^{-2}$	SCALE1(52)	10		
		$SUM2_{SW(1)}$	$W\text{-}hm^{-22}$	SCALE1(53)	1		
		$SUM2_{SW(2)}$	$W\text{-}hm^{-22}$	SCALE1(54)	10		
		$\overline{M}_{LW}$:	Wm^{-2}	SCALE1(55)	10		
		$M_{MIN_{LW}}$	Wm^{-2}	SCALE1(56)	10		
		$M_{MAX_{LW}}$	Wm^{-2}	SCALE1(57)	10		
		σ_{LW}:	Wm^{-2}	SCALE1(58)	100		
		N_{LW}	---	SCALE1(59)	1		
		$SUM_{LW(1)}$	$W\text{-}hm^{-2}$	SCALE1(60)	1		
		$SUM_{LW}(2)$	$W\text{-}hm^{-2}$	SCALE1(61)	10		
		$SUM2_{LW(1)}$	$W\text{-}hm^{-22}$	SCALE1(62)	1		
		$SUM2_{LW(2)}$	$W\text{-}hm^{-22}$	SCALE1(63)	10		
		$\overline{\alpha}$:	---	SCALE1(64)	10000		
		SOLARH(1)	$W\text{-}hm^{-2}$	SCALE1(65)	1		
		SOLARH(2)	$W\text{-}hm^{-2}$	SCALE1(66)	10		15632
Monthly	978	$N_{HR\text{-}DAY}$	---	SCALE1(67)	1	1	
	979	NOAA-9 Deadscanner Flag**	---	SCALE1(67)	1	1	
	980	ERBS Deadscanner Flag**	---	SCALE1(67)	1	1	
	981	NOAA-10 Deadscanner Flag**	---	SCALE1(67)	1	1	
	982	Half-sine Flag**	---	SCALE1(67)	1	1	
	983 - 990	Spares	-	-	0	9	15840
Hourly/ Day*	1	Hour box	---	SCALE2(1)	1	1	16
	2	Whole Julian date(1)	day	SCALE2(2)	1	1	32
	3	Whole Julian date(2)	day	SCALE2(3)	1	1	48
	4	Fractional Julian date	day	SCALE2(4)	10000	1	64

	5-13	Scene fraction(9)	---	SCALE2(5)	10000	1	208
	14-22	$\overline{\alpha}$ (9)	---	SCALE2(6)	10000	1	352
	23	$COS(ZEN)_{SUN}$	---	SCALE2(7)	10000	1	368
	24	Satellite zenith angle	degrees	SCALE2(8)	100	1	384
	25	Azimuth angle	degrees	SCALE2(9)	100	1	400
	26	SOLAR	Wm^{-2}	SCALE2(10)	10	1	416
	27	$\overline{M}_{SW}$	Wm^{-2}	SCALE2(11)	10	1	432
	28	$M_{MIN_{SW}}$	Wm^{-2}	SCALE2(12)	10	1	448
	29	$M_{MAX_{SW}}$	Wm^{-2}	SCALE2(13)	10	1	464
	30	σ_{SW}	Wm^{-2}	SCALE2(14)	100	1	480
	31	N_{SW}	---	SCALE2(15)	1	1	496
	32	$\overline{M}_{LW}$	Wm^{-2}	SCALE2(16)	10	1	512
	33	$M_{MIN_{LW}}$	Wm^{-2}	SCALE2(17)	10	1	528
	34	$M_{MAX_{LW}}$	Wm^{-2}	SCALE2(18)	10	1	544
	35	σ_{LW}	Wm^{-2}	SCALE2(19)	10	1	560
	36	N_{LW}	---	SCALE2(20)	1	1	576
	37	$M_{DIFF_{SW}}$	Wm^{-2}	SCALE2(21)	100	1	592
	38	$M_{DIFF_{LW}}$	Wm^{-2}	SCALE2(22)	100	1	608*

** Repeated $N_{HR\text{-}DAY}$ times*
*** See Section 9.3.1*

Table 6: Scanner Output Product (S-9)

Temporal Scale	Statistics/Parameters	Output Structure	
		No. of Data Values	Record
	Regional number, Geographic scene type, Scene fraction histogram(4)	6	1
Monthly (Day)	$\overline{M}_{SW}$, $M_{MIN_{SW}}$, $M_{MAX_{SW}}$, σ_{SW}, N_{SW}, $\overline{M}_{LW}$, $M_{MIN_{LW}}$, $M_{MAX_{LW}}$, σ_{LW}, N_{LW}, $\overline{\alpha}$, $\overline{M}_{NET}$, TSOLRD(2), $\overline{M}_{SW}$ CS, $M_{MIN_{SW_{CS}}}$, $M_{MAX_{SW_{CS}}}$, $\sigma_{SW_{CS}}$, $N_{SW_{CS}}$, $\overline{M}_{LW}$ CS, $M_{MIN_{LW_{CS}}}$, $M_{MAX_{LW_{CS}}}$, $\sigma_{LW_{CS}}$, $N_{LW_{CS}}$, $\overline{\alpha}$ CS, $\overline{M}_{NET}$ CS, $TSOLRD(2)_{CS}$	28 x 1	
Monthly (Hour)	$\overline{M}_{SW}$, $M_{MIN_{SW}}$, $M_{MAX_{SW}}$, σ_{SW}, N_{SW}, $\overline{M}_{LW}$, $M_{MIN_{LW}}$, $M_{MAX_{LW}}$, σ_{LW}, N_{LW}, $\overline{\alpha}$, $\overline{M}_{NET}$, TSOLRD(2), $\overline{M}_{SW}$ CS, $M_{MIN_{SW_{CS}}}$, $M_{MAX_{SW_{CS}}}$, $\sigma_{SW_{CS}}$, $N_{SW_{CS}}$, $\overline{M}_{LW}$ CS, $M_{MIN_{LW_{CS}}}$, $M_{MAX_{LW_{CS}}}$, $\sigma_{LW_{CS}}$, $N_{LW_{CS}}$, $\overline{\alpha}$ CS, $\overline{M}_{NET}$ CS, $TSOLRD(2)_{CS}$	28 x 1	
Daily	DEO, $\overline{M}_{SW}$, $M_{MIN_{SW}}$, $M_{MAX_{SW}}$, σ_{SW}, N_{SW}, $\overline{M}_{LW}$, $M_{MIN_{LW}}$, $M_{MAX_{LW}}$, σ_{LW}, N_{LW}, $\overline{\alpha}$, SOLARD(2), $\overline{M}_{SW}$, $M_{MIN_{SW_{CS}}}$, $M_{MAX_{SW_{CS}}}$, σ_{SW} CS, $N_{SW_{CS}}$, $\overline{M}_{LW}$ CS, $M_{MIN_{LW_{CS}}}$, $M_{MAX_{LW_{CS}}}$, σ_{LW} CS, N_{LWCS}, $\overline{\alpha}$ CS	25 x 31	
Monthly Hourly	$\overline{M}_{SW}$, $M_{MIN_{SW}}$, $M_{MAX_{SW}}$, σ_{SW}, N_{SW}, $SUM_{SW}(2)$, $SUM2_{SW}(2)$, $\overline{M}_{LW}$ $M_{MIN_{LW}}$, $M_{MAX_{LW}}$, σ_{LW}, N_{LW},	42 x 24	

	$SUM_{LW}(2)$, $SUM2_{LW}(2)$, $\overline{\alpha}$, SOLARH(2), $\overline{M}_{SW}$ CS, $M_{MIN_{SW_{CS}}}$, $M_{MAX_{SW_{CS}}}$, σ_{SW} CS, $N_{SW_{CS}}$, $SUM_{SW_{CS}}(2)$, $SUM2_{SW_{CS}}(2)$, $\overline{M}_{LW}$ CS, $M_{MIN_{LW_{CS}}}$, $M_{MAX_{LW_{CS}}}$, σ_{LW} CS, $N_{LW_{CS}}$, $SUM_{LW_{CS}}(2)$, $SUM2_{LW_{CS}}(2)$, $\overline{\alpha}$ CS, SOLARH(2)		
Monthly	$N_{HR\text{-}DAY}$	1	-
	Spares	14	-
Hourly/Day	Hour box, Whole Julian date(2), Fractional Julian date, Scene fraction (9), $\overline{\alpha}$ (9), $COS(ZEN)_{SUN}$, Satellite zenith angle, Azimuth angle, SOLAR, $\overline{M}_{SW}$, $M_{MIN_{SW}}$, $M_{MAX_{SW}}$, σ_{SW}, N_{SW}, $\overline{M}_{LW}$, $M_{MIN_{LW}}$, $M_{MAX_{LW}}$, σ_{LW}, N_{LW}, $\underline{M_{DIFF_{SW}}}$, $M_{DIFF_{LW}}$, $\overline{\alpha}$ CS, CS, σ_{LW}, $N_{LW_{CS}}$	32 x $N_{HR\text{-}DAY}$	2

Table 7: Nonscanner Output Product (S-10)

Temporal Scale	Statistics/Parameters	Output Structure	
		No. of Data Values	**Record**
	Regional number, Geographic scene type, Scene fraction histogram(9)	11	1
Monthly (Day)	$\overline{M}_{SW}$, $M_{MIN_{SW}}$, $M_{MAX_{SW}}$, σ_{SW}, N_{SW}, $\overline{M}_{LW}$, $M_{MIN_{LW}}$, $M_{MAX_{LW}}$, σ_{LW}, N_{LW}, $\overline{\alpha}$, $\overline{M}_{NET}$, TSOLRD(2)	28 x 1	
Monthly (Hour)	$\overline{M}_{SW}$, $M_{MIN_{SW}}$, $M_{MAX_{SW}}$, σ_{SW}, N_{SW}, $\overline{M}_{LW}$, $M_{MIN_{LW}}$, $M_{MAX_{LW}}$, σ_{LW}, N_{LW}, $\overline{\alpha}$, $\overline{M}_{NET}$, TSOLRH(2)		
Daily	DEO, $\overline{M}_{SW}$, $M_{MIN_{SW}}$, $M_{MAX_{SW}}$, σ_{SW}, N_{SW}, $\overline{M}_{LW}$ $M_{MIN_{LW}}$, $M_{MAX_{LW}}$, σ_{LW}, N_{LW}, $\overline{\alpha}$, SOLARD(2)	14 x 31	
Monthly Hourly	$\overline{M}_{SW}$, $M_{MIN_{SW}}$, $M_{MAX_{SW}}$, σ_{SW}, N_{SW}, $SUM_{SW}(2)$, $SUM2_{SW}(2)$, $\overline{M}_{LW}$ $M_{MIN_{LW}}$, $M_{MAX_{LW}}$, σ_{LW}, N_{LW}, $SUM_{LW}(2)$, $SUM2_{LW}(2)$, $\overline{\alpha}$, SOLARH(2)	21 x 24	
Monthly	$N_{HR\text{-}DAY}$	1	
	NOAA-9 Deadscanner Flag	1	
	ERBS Deadscanner Flag	1	
	NOAA-10 Deadscanner Flag	1	
	Half-sine Flag	1	
	Spares	9	
Hourly/Day	Hour box, Whole Julian date(2), Fractional Julian date, Scene fraction (9), $\overline{\alpha}$ (9), $COS(ZEN)_{SUN}$, Satellite zenith angle, Azimuth angle, SOLAR, $\overline{M}_{SW}$, $M_{MIN_{SW}}$, $M_{MAX_{SW}}$, σ_{SW}, N_{SW}, $\overline{M}_{LW}$, $M_{MIN_{LW}}$, $M_{MAX_{LW}}$, σ_{LW}, N_{LW}, $\underline{M_{DIFF_{SW}}}$, $M_{DIFF_{LW}}$	38 x $N_{HR\text{-}DAY}$	2

Variable Description/Definition:

In the following definitions, some values are listed as occupying two words. These parameters require two 16-bit words to represent a sufficient number of significant digits. To restore the value in the two words, multiply the value of the first 16-bit word by the appropriate scale factor (see Table 5) and add on the value in the second 16-bit word.

S-9

Scanner Output Product (S-9) values are represented in Table 6. For each parameter listed below, the units are given in parenthesis and the numbers in brackets identify the possible range.

Interpretation of S-9 Record 1 Quantities

S-9(1) - Region Number:
An integer from 1 to 10368 denotes one of the 2.5 x 2.5 degree ERBE regions. Region 1 lies in the range 87.5°<lat<=90° (0°<=colat<2.5°), 0°<=long<2.5°. The regions are numbered consecutively, west to east, 144 per latitude band. The last row of regions includes a latitude of -90 degrees (colat = 180 degrees) (Reference 3).

S-9(2) - Geographic scene type:
An integer from 1-5 denotes the surface type of the region. The types are:

- 1 = ocean
- 2 = land
- 3 = snow
- 4 = desert
- 5 = land/ocean mix (coastal regions)

For the land/ocean mix, the corresponding directional models (clear, partly cloudy, or mostly cloudy over this scene) are linear composites of land and ocean models and not independent models.

S-9(3-6) - Scene fraction histogram:
The sum of all scene fractions for one month for clear, partly cloudy, mostly cloudy, and overcast scenes. [0-744]

S-9(7-34) - Monthly (day) quantities:
Monthly means based on daily calculations of flux. For longwave flux quantities, the daily means are obtained from the extrapolation, interpolation, and diurnal modeling algorithms that operate on the existing longwave estimates. The extrapolation and interpolation algorithms will, in general, cross daily boundaries, but the longwave diurnal model applied to land scenes operates on a specific day.

The shortwave flux quantities are based on calculations for specific days. The days are defined to be symmetric about local solar noon.

Values for all Cloud Conditions

$\overline{M}_{SW}$: The monthly mean shortwave flux (SWF) based on the monthly mean albedo, the $\overline{\alpha}$, and the sum of the integrated solar incidence, (S(d)) over the entire month.

$$\overline{M}_{SW} = \overline{\alpha} \cdot \sum_{d=1}^{N} S(d) / (24 \cdot N) \qquad (1)$$

where N = all days of month.

The solar incidence is integrated sunrise to sunset for each day with SWF data, assuming a sun position for the day that is fixed at its position for $0^h0^m0^s$ UT.

- $M_{MIN_{SW}}$: minimum daily mean for days with at least one SWF estimate. (Wm^{-2})
- $M_{MAX_{SW}}$: maximum daily mean for days with at least one SWF estimate. (Wm^{-2})
- σ_{SW} standard deviation of daily means for days with at least one SWF estimate. (Wm^{-2})
- N_{SW}: the number of days with at least one SWF estimate. [1-31]

$\overline{M}_{LW}$: the monthly mean LWF based on all extrapolated, interpolated, and modeled LWF values for the month in this region. (Wm^{-2})

$$\overline{M}_{LW} = \sum_{d=1}^{N} \sum_{h=1}^{24} M_{LW}(d,h) / (24 \cdot N)$$

where N = all days of month. (Reference 4)

- $M_{MIN_{LW}}$: the minimum daily mean of the LWF for the month. (Wm^{-2})
- $M_{MAX_{LW}}$: the maximum daily mean of the LWF for the month. (Wm^{-2})

- σ_{LW} standard deviation for the LWF daily means for every day in the month. (Wm^{-2})

- N_{LW}: number of days with at least one LWF estimate. [1-31]

  $\bar{\alpha}$: the monthly mean albedo from daily values based on the sum of all integrated daily SWFs calculated for days with at least one SWF estimate (D_{sw}) [0-1.0] (Reference 4)

  $$\bar{\alpha} = 24 \cdot \sum_{D_{SW}} M_{SW}(d) / \sum_{D_{SW}} S(d)$$

  $\bar{M}_{NET}$: the monthly net flux defined from albedo, the sum of integrated solar incidence over the entire month, and monthly net LWF. (Wm^{-2})

  $$\bar{M}_{NET} = \left[(1-\bar{\alpha}) \cdot \sum_{d=1}^{N} S(d) / (24 \cdot N)\right] - M_{LW}$$

- TSOLRD (2 words): the monthly total integrated solar incidence for the entire month. The multiple of 10 used to separate this value is 1000. ((W-hm^{-2})$^{-2}$)

Values for clear-sky conditions

  $\bar{M}_{SW_{CS}}$: the monthly mean SWF based on the monthly mean clear-sky albedo and the sum of integrated solar incidence over the entire month. (Wm^{-2})

  $$\bar{M}_{SW_{CS}} = \bar{\alpha}_{CS} \cdot \sum_{d=1}^{N} S(d) / (24 \cdot N)$$

  where N = all days of month.

- $M_{MIN_{SW_{cs}}}$: minimum daily mean for days with at least one clear-sky SWF estimate. (Wm^{-2})

- $M_{MAX_{SW_{cs}}}$: maximum daily mean for days with at least one clear-sky SWF estimate. (Wm^{-2})

- $\sigma_{SW_{cs}}$ the standard deviation of daily means for days with at least one clear-sky SWF estimate.(Wm^{-2})

- $N_{SW_{CS}}$: the number of days with at least one clear-sky SWF estimate. [1-31]

  $\bar{M}_{LW_{CS}}$: the monthly mean LWF based on all extrapolated, interpolated, and modeled clear-sky LWF values for the month in this region. (Wm^{-2})

  $$\bar{M}_{LW_{CS}} = \sum_{d=1}^{N} \sum_{h=1}^{24} M_{LW}(d,h) / (24 \cdot N)$$

  where N = all days of month.

  This equation applies to ocean scenes. For land regions, the calculation of $\bar{M}_{LW_{CS}}$ is described in the Special Corrections/Adjustments Section of this document.

- $M_{MIN_{LW_{cs}}}$: the minimum daily mean of the clear-sky LWF for the month. (Wm^{-2})

- $M_{MAX_{LW_{cs}}}$: the maximum daily mean of the clear-sky LWF for the month. (Wm^{-2})

- $\sigma_{LW_{CS}}$ standard deviation for the clear-sky LWF daily means for every day in the month. (Wm^{-2})

- $N_{LW_{CS}}$: number of days with at least one clear-sky LWF estimate. [1-31]

  $\bar{\alpha}_{CS}$: the monthly mean albedo from daily values, based on the sum of all integrated daily SWFs calculated for days with at least one clear-sky SWF estimate. ($D_{sw_{cs}}$) [0-1.0]

  $$\bar{\alpha}_{CS} = 24 \cdot \sum_{D_{SW_{CS}}} M_{SW}(d) / \sum_{D_{SW_{CS}}} S(d)$$

  $\bar{M}_{NET_{CS}}$: the monthly net flux defined from $\bar{\alpha}_{CS}$, the sum of integrated solar incidence over the entire month, and monthly net clear-sky LWF. (Wm^{-2})

  $$\bar{M}_{NET_{CS}} = \left[(1-\bar{\alpha}_{CS}) \cdot \sum_{d=1}^{N} S(d) / (24 \cdot N)\right] - M_{LW_{CS}}$$

- $TSOLRD_{cs}$ (2 words): the monthly total integrated solar incidence for the entire month. The multiple of 10 used to separate this value is 1000. ($W\text{-}hm^{-2}$)

S-9(35-62) - Monthly (hour) quantities:
These are monthly means based on values averaged over the month at each local hour. In general, they result in different values for the same radiometric quantity, compared to the monthly (day) means.

Values for all Cloud Conditions

$\overline{M}_{SW}$: the monthly mean SWF based on the monthly mean albedo and the sum of integrated solar incidence over the entire month. (Wm^{-2})

$$\overline{M}_{SW} = \bar{\alpha} \cdot \sum_{d=1}^{N} S(d) / (24 \cdot N)$$

where N = all days of month.

- $M_{MIN_{sw}}$: the minimum monthly hourly mean SWF, as calculated for days with at least one SWF estimate. It can be zero if there is at least one nighttime hour during the month. (Wm^{-2})
- $M_{MAX_{sw}}$: the maximum monthly hourly mean SWF, as calculated for days with at least one SWF estimate. (Wm^{-2})
- σ_{SW} the standard deviation of all monthly (hour) mean SWFs including nighttime values. This value may be a large number without much physical significance. (Wm^{-2})
- N_{SW}: the number of hours that had at least one SWF estimate during the month. [1-24]

$\overline{M}_{LW}$: the monthly mean LWF based on extrapolated, interpolated, and modified LWF values only for days during the month that had at least one actual LWF estimate. (Wm^{-2}) (Reference 4)

$$\overline{M}_{LW} = \sum_{h=1}^{24} M_{LW}(h) / 24$$

- $M_{MIN_{LW}}$: the minimum LWF for days with at least one LWF estimate. (Wm^{-2})
- $M_{MAX_{LW}}$: the maximum LWF for days with at least one LWF estimate. (Wm^{-2})
- σ_{LW} the standard deviation of all monthly (hour) mean LWFs for days with at least one LWF estimate. (Wm^{-2})
- N_{LW}: the number of hours that had at least one LWF estimate during the month. [1-24]

$\bar{\alpha}$: the monthly mean albedo from monthly hourly values, based on the sum of all SWFs calculated for days with at least one SWF estimate. [0-1.0]

$$\bar{\alpha} = 24 \cdot \sum_{D_{SW}} M_{SW}(d) / \sum_{D_{SW}} S(d)$$

where, D_{sw} = days with at least one SWF measurement.

$\overline{M}_{NET}$: the monthly net flux defined from $\bar{\alpha}$, the sum of integrated solar incidence over the entire month, and monthly net LWF defined from days with at least one LWF estimate. Wm^{-2}

$$\overline{M}_{NET} = \left[(1 - \bar{\alpha}) \cdot \sum_{d=1}^{N} S(d) / (24 \cdot N) \right] - M_{LW}$$

- TSOLRH (2 words): the monthly total integrated solar incidence for the entire month. The multiple of 10 used to separate this value is 1000. ($W\text{-}hm^{-2}$)

Values for clear-sky conditions

$\overline{M}_{SW_{CS}}$: the monthly mean SWF based on the monthly mean clear-sky albedo and the integrated solar incidence over the entire month. (Wm^{-2})

$$\overline{M}_{SW_{CS}} = \overline{\alpha}_{CI} \cdot \sum_{d=1}^{N} S(d) / (24 \cdot N)$$

where N = all days of month.

- $M_{MIN_{SW_{cs}}}$: the minimum monthly hourly mean SWF, as calculated for days with at least one clear-sky SWF estimate. It can be zero if there is at least one nighttime hour during the month. (Wm^{-2})
- $M_{MAX_{SW_{cs}}}$: the maximum monthly hourly mean SWF, as calculated for days with at least one clear-sky SWF estimate. (Wm^{-2})
- $\sigma_{SW_{cs}}$ the standard deviation of all monthly (hour) mean SWFs including clear-sky SWF nighttime values. This value may be a large number without much physical significance. (Wm^{-2})
- $N_{SW_{CS}}$: the number of hours that had at least one clear-sky SWF estimate during the month. [1-24]

$\overline{M}_{LW_{CS}}$: the monthly mean LWF based on extrapolated, interpolated, and modeled clear-sky LWF values only for days during the month that had at least one actual clear-sky LWF estimate. (Wm^{-2}) (Reference 4)

$$\overline{M}_{LW_{CS}} = \sum_{h=1}^{24} M_{LW_{CS}}(h) / 24$$

This equation applies to ocean scenes; for land regions, the calculation of $\overline{M}_{LW_{CS}}$ is described in the Special Corrections/Adjustments Section of this document.

- $M_{MIN_{LW_{cs}}}$: the minimum LWF for days with at least one clear-sky LWF estimate. (Wm^{-2})
- $M_{MAX_{LW_{cs}}}$: the maximum LWF for days with at least one clear-sky LWF estimate. (Wm^{-2})
- $\sigma_{LW_{CS}}$ the standard deviation of all monthly (hour) mean LWFs for days with at least one clear-sky LWF estimate. (Wm^{-2})
- $N_{LW_{CS}}$: the number of hours that had at least one clear-sky LWF estimate during the month. [1-24]

$\overline{\alpha}_{CS}$: the monthly mean albedo from monthly hourly values, based on the sum of all SWFs calculated for days with at least one clear-sky SWF estimate. [0-1.0]

$$\overline{\alpha}_{CS} = 24 \cdot \sum_{D_{SW_{CS}}} M_{SW}(d) / \sum_{D_{SW_{CS}}} S(d)$$

where, $\overline{\alpha}_{\iota}$ = days with at least one clear-sky SWF measurement. (Reference 4)

$\overline{M}_{NET_{CS}}$: the monthly net flux defined from $\overline{\alpha}_{CS}$, the sum of integrated solar incidence over the entire month, and monthly net LWF defined from days with at least one clear-sky LWF estimate. (Wm^{-2})

$$\overline{M}_{NET_{CS}} = \left[(1 - \overline{\alpha}_{CS}) \cdot \sum_{d=1}^{N} S(d) / (24 \cdot N) \right] - \overline{M}_{LW_{CS}}$$

- $TSOLRD_{CS}$ (2 words): the monthly total integrated solar incidence for the entire month. The multiple of 10 used to separate this value is 1000. (Wm^{-2})

S-9(63-837) - Daily quantities:
These are quantities calculated for each day in the month; i.e., there are 31 sets of values on the file. A set consists of the following values.

Values for all Cloud Conditions

- DEO: the distance-corrected solar constant for the day. (Wm^{-2})

$\overline{M}_{SW}$: for each day with at least one SWF estimate, the sum of all estimates and modeled SWFs, divided by 24, and corrected by the ratio of integrated to summed solar incidence. This value is called the integrated daily SWF. (Wm^{-2})

$$\overline{M}_{SW}(d) = [S(d) / S'(d)] \cdot \sum_{h=1}^{24} M_{SW}(h) / 24$$

where S(d) and S'(d) are the integrated and summed solar radiances, respectively. (Reference 4)

- $M_{MIN_{SW}}$: the minimum estimated or modeled SWF for the day. This value will be zero days with at least one nighttime hour. (Wm^{-2})

- $M_{MAX_{SW}}$: the maximum estimated or modeled SWF for the day. (Wm^{-2})

- σ_{SW} the standard deviation of all modeled or estimated SWF values for the day. This may be a large number without much physical significance for days having at least one nighttime hour. (Wm^{-2})

- N_{SW}: the number of hours with SWF estimates for the day. [1-24]

$\overline{M}_{LW}$: daily LWF consisting of estimates and extrapolated, interpolated, and modeled values. (Wm^{-2}

- $M_{MIN_{LW}}$: the minimum estimated or modeled LWF for the day. (Wm^{-2})

- $M_{MAX_{LW}}$: the maximum estimated or modeled LWF for the day. (Wm^{-2})

- σ_{LW} the standard deviation of all modeled or estimated LWFs for the day. (Wm^{-2})

- N_{LW}: the number of hours with LWF estimates for the day. [1-24]

$\overline{\alpha}$: the daily albedo defined as the ratio of integrated daily SWF to the integrated daily solar incidence. [0-1.0]

$$\overline{\alpha}(d) = \overline{M}_{SW}(d)/S(d)$$

where S(d) = integrated daily solar incidence. (Reference 4)

- SOLARD (2 words): integrated solar incidence over a day. The multiple of 10 used to separate this value is 1000. (W-hm^{-2})

Values for clear-sky conditions

$\overline{M}_{SW_{CS}}$: for each day with at least one clear-sky SWF estimate, the sum of all estimates and modeled SWFs, divided by 24, and corrected by the ratio of integrated to summed solar incidence. This value is called the integrated clear-sky SWF. (Wm^{-2}) (Reference 4)

$$\overline{M}_{SW_{CS}}(d) = [S(d)/S'(d)] \cdot \sum_{h=1}^{24} M_{SW_{CS}}(h)/24$$

- $M_{MIN_{SW_{cs}}}$: the minimum estimated or modeled clear-sky SWF for the day. This value will be zero for days with at least one nighttime hour.

- $M_{MAX_{SW_{cs}}}$: the maximum estimated or modeled clear-sky SWF for the day. (Wm^{-2})

- $\sigma_{SW_{cs}}$ the standard deviation of all modeled or estimated clear-sky SWF values for the day. This may be a large number without much physical significance for days having at least one nighttime hour. (Wm^{-2})

- $N_{SW_{cs}}$: the number of hours with clear-sky SWF estimates for the day. [1-24]

$\overline{M}_{LW_{CS}}$: daily clear-sky LWF consisting of estimates and extrapolated, interpolated, and modeled values. (Wm^{-2})

- $M_{MIN_{LW_{cs}}}$: the minimum estimated or modeled clear-sky LWF for the day. (Wm^{-2})

- $M_{MAX_{LW_{cs}}}$: the maximum estimated or modeled clear-sky LWF for the day. (Wm^{-2})

- $\sigma_{LW_{cs}}$ the standard deviation of all modeled or estimated clear-sky LWFs for the day. (Wm^{-2})

- $N_{LW_{cs}}$: the number of hours with clear-sky LWF estimates for the day. [1-24]

$\overline{\alpha}_{CS}$: the daily albedo defined as the ratio of integrated daily clear-sky SWF to the integrated daily solar incidence. [0-1.0]

$$\overline{\alpha}_{CS}(d) = \overline{M}_{SW_{CS}}(d)/S(d)$$

where S(d) = integrated daily solar incidence (Reference 4)

S-9(838-1845) - Monthly hourly quantities:
These are calculated for the month at each local hour; i.e., there are 24 sets of values on the file. A set consists of the following values.

Values for all Cloud Conditions

$\overline{M}_{SW}$: the monthly hourly mean SWF for this hour. (Wm^{-2})

- $M_{MIN_{sw}}$: the minimum SWF for this hour. This value will be zero for nighttime hours. (Wm^{-2})
- $M_{MAX_{sw}}$: the maximum SWF for this hour. (Wm^{-2})
- σ_{SW} the standard deviation for SWFs at this hour. (Wm^{-2})
- N_{SW}: the number of days with SWF estimates for the hour. [1-31]
- SUM_{sw} (2 words), $SUM2_{sw}$ (2 words): the sum and sum squared of actual SWF estimates at this hour. These values are intended for doing tests of statistical significance for diurnal variability. The multiple of 10 used to separate these values is 1000. ($W\text{-}hm^{-2}$), ($(W\text{-}hm^{-2})^{-2}$)

$\overline{M}_{LW}$: the monthly hourly average LWF for this hour. Wm^{-2})

- $M_{MIN_{LW}}$: the minimum LWF for days with LWF estimates at the hour. (Wm^{-2})
- $M_{MAX_{LW}}$: the maximum LWF for days with LWF estimates at the hour. (Wm^{-2})
- σ_{LW} the standard deviation for LWF for days with LWF estimates at the hour. (Wm^{-2})
- N_{LW}: the number of days with LWF estimates at the hour. [1-31]
- SUM_{LW} (2 words), $SUM2_{LW}$ (2 words): sum and sum squared of actual LWF estimates at this hour. These values are intended for doing tests of statistical significance on diurnal variability. The multiple of 10 used to separate these values is 1000. ($W\text{-}hm^{-2}$), ($(W\text{-}hm^{-2})^{-2}$)

$\overline{\alpha}$: monthly hourly albedo defined as the ratio of monthly hourly SWF to the integrated solar incidence. [0-1.0]

- SOLARH (2 words): integrated solar incidence over those days with SWF data for a given hour. The multiple of 10 used to separate this value is 1000. ($W\text{-}hm^{-2}$)

Values for clear-sky conditions

$\overline{M}_{SW_{CS}}$: the monthly hourly mean clear-sky SWF for this hour. (Wm^{-2})

- $M_{MIN_{SW_{cs}}}$: the minimum clear-sky SWF for this hour. This value will be zero for nighttime hours. (Wm^{-2})
- $M_{MAX_{SW_{cs}}}$: the maximum clear-sky SWF for this hour. (Wm^{-2})
- $\sigma_{SW_{cs}}$ the standard deviation for clear-sky SWF for this hour. (Wm^{-2})
- $N_{SW_{CS}}$: the number of days with clear-sky SWF estimates for the hour. [1-31]
- $SUM_{SW_{CS}}$ (2 words), $SUM2_{SW_{CS}}$ (2 words): the sum and sum squared of actual clear-sky SWF estimates at this hour. These values are intended for doing tests of statistical significance for diurnal variability. The multiple of 10 used to separate these values is 1000. ($W\text{-}hm^{-2}$), ($(W\text{-}hm^{-2})^{-2}$)

$\overline{M}_{LW_{CS}}$: the monthly hourly average clear-sky LWF for this hour. (Wm^{-2})

- $M_{MIN_{LW_{cs}}}$: the minimum clear-sky LWF for days with LWF estimates at the hour. (Wm^{-2})
- $M_{MAX_{LW_{cs}}}$: the maximum clear-sky LWF for days with LWF estimates at the hour. (Wm^{-2})
- $\sigma_{LW_{CS}}$ the standard deviation for LWF for days with clear-sky LWF estimates at the hour. (Wm^{-2})
- $N_{LW_{CS}}$: the number of days with clear-sky LWF estimates at the hour. [1-31]
- $SUM_{LW_{CS}}$ (2 words), $SUM2_{LW_{CS}}$ (2 words): the sum and sum squared of actual clear-sky LWF estimates at this hour. These values for doing clear-sky tests of statistical significance on diurnal variability. The multiple of 10 used to separate these values is 1000. ($W\text{-}hm^{-2}$), ($(W\text{-}hm^{-2})^{-2}$)

$\overline{\alpha}_{CS}$: monthly hourly albedo defined as the ratio of monthly hourly clear-sky SWF to the summed integrated solar incidence. [0-1.0]

- $SOLARH_{CS}$ (2 words): integrated solar incidence over those days with SWF data for a given hour. The multiple of 10 used to separate this value is 1000. ($W\text{-}hm^{-2}$)

S-9(1846) - Number of Hour Boxes:
The total number of hours in the month with one or more estimates of any kind. Record 2 length in words is determined by $N_{HR\text{-}DAY}$ times 32.

Interpretation of S-9 Record 2 Quantities

The Hourly/Day estimates constitute the individual estimates as received from the Inversion Subsystem and adjusted to the conditions at the local solar half hour with the aid of directional models appropriate to the scene types represented in Table 8, Table 9, and Table 10.

Table 8: Normalized Directional Models

	Solar Zenith Angle Bin Number										
Scanner Index	**0.95**	**0.85**	**0.75**	**0.65**	**0.55**	**0.43**	**0.35**	**0.25**	**0.15**	**0.05**	**Nonscanner Index**
(Clear)	1.00000	1.07895	1.19737	1.32895	1.51316	1.75000	2.11842	2.67105	3.52632	4.39474	1 (Ocean)
2	1.00000	.97813	1.01875	1.04375	1.09375	1.16438	1.28125	1.44375	1.68750	2.03750	2 (Land)
3	1.00000	1.00450	1.00899	1.01289	1.01588	1.01738	1.01514	1.00525	.97437	.92747	3 (Snow)
4	1.00000	1.02000	1.04800	1.08300	1.12600	1.17600	1.23400	1.30000	1.37200	1.45300	4 (Desert)
5[+]	1.00000	1.01059	1.07627	1.13559	1.22881	1.35297	1.55085	1.83898	2.27966	2.79661	Clear
(Partly Cloudy) 6	1.00000	1.12000	1.20000	1.36000	1.48000	1.72000	2.00000	2.40000	2.92000	3.56000	5 (Ocean)
7 *	1.00000	1.03756	1.07981	1.13146	1.19249	1.29108	1.41315	1.59624	1.77465	2.01174	6 (Land/Desert)[++] Partly Cloudy
8 *	1.00000	1.03756	1.07981	1.13146	1.19249	1.29108	1.41315	1.59624	1.77465	2.01174	
9 *	1.00000	1.03756	1.07981	1.13146	1.19249	1.29108	1.41315	1.59624	1.77465	2.01174	
10[+]	1.00000	1.06805	1.12426	1.21598	1.29882	1.44970	1.63018	1.89349	2.19822	2.58432	
(Mostly Cloudy) 11	1.00000	1.07843	1.13725	1.23529	1.29412	1.43137	1.56863	1.75686	1.96078	2.19608	7 (Ocean)
12 *	1.00000	1.04700	1.10300	1.17000	1.24400	1.33200	1.42800	1.53400	1.65000	1.77500	8 (Land/Desert)[++] Mostly Cloudy
13 *	1.00000	1.04700	1.10300	1.17000	1.24400	1.33200	1.42800	1.53400	1.65000	1.77500	
14 *	1.00000	1.04700	1.10300	1.17000	1.24400	1.33200	1.42800	1.53400	1.65000	1.77500	
15 *	1.00000	1.08468	1.16216	1.25586	1.35135	1.46613	1.61171	1.77658	1.94685	2.14775	
(Overcast) 16	1.00000	1.02353	1.07059	1.12941	1.17647	1.24706	1.31765	1.38824	1.45882	1.51765	9 Overcast

Directional Model Index Selection for Scanner Measurements

Geotype(G) = 1 (Ocean) and f_i = 1 (Clear) Then if f_i = 1, INDEX = G
Geotype(G) = 2 (Land) and f_i = 2 (Partly cloudy) Then if f_i = 2, INDEX = G + 5
Geotype(G) = 3 (Snow) and f_i = 3(Mostly cloudy) Then if f_i = 3, INDEX = G + 10
Geotype(G) = 4 (Desert) and f_i = 4 (Overcast) Then if f_i = 4, INDEX = 16
Geotype(G) = 5 (Land/Ocean)[+]

** Storing separate but identical models for land, snow, desert, and land/desert mix makes easier the generation of a scanner model index from cloud and geotype information.*
[+] *These are linear composite models (50-50 for each constituent), not independent models, which function as separate scene tyeps for scanner processing.*
[++] *Snow geotypes must be either clear or overcast.*

Table 9: ERBE Directional Albedo Models

Model No.	Solar Zenith Angle Bin Number									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	.0760	.0820	.0910	.1010	.150	.1330	.1610	.2030	.2680	.3340
2	.1600	.1565	.1630	.1670	.1750	.1863	.2050	.2310	.2700	.3260

3	.6673	.6703	.6733	.6759	.6779	.6789	.6774	.6708	.6502	.6189
4	.2369	.2388	.2411	.2437	.2471	.2517	.2581	.2683	.2864	.3098
5	.1180	.1193	.1270	.1340	.1450	.1597	.1830	.2170	.2690	.3300
6	.1250	.1400	.1500	.1700	.1850	.2150	.2500	.3000	.3650	.4450
7	.2130	.2210	.2300	.2410	.2540	.2750	.3010	.3400	.3780	.4285
8	.1690	.1805	.1900	.2055	.2195	.2450	.2755	.3200	.3715	.4368
9	.2550	.2750	.2900	.3150	.3300	.3650	.4000	.4480	.5000	.5600
10	.3000	.3270	.3550	.3820	.4200	.4487	.4945	.5380	.5805	.6320
11	.2775	.3010	.3225	.3485	.3750	.4069	.4473	.4930	.5403	.5960
12	.4250	.4350	.4550	.4800	.5000	.5300	.5600	.5900	.6200	.6450

Table 10: ERBE Scene Types

Model No.	Scene	Cloud Cover (Percent)
1	Ocean	0 < C < 5
2	Land	0 < C < 5
3	Snow	0 < C < 5
4	Desert	0 < C < 5
5	Mixed, Land-Ocean	0 < C < 5
6	Partly cloudy over ocean	5 < C < 50
7	Partly cloudy over land or desert	5 < C < 50
8	Partly cloudy over land-ocean mix	5 < C < 50
9	Mostly cloudy over ocean	50 < C < 95
10	Mostly cloudy over land or desert	50 < C < 95
11	Mostly cloudy over land-ocean mix	50 < C < 95
12	Overcast	95 < C < 100

S-9(1) - Hour box:
This is an integer from 1-744 designating the local solar hour box to which the estimate has been assigned. (Hours run from 1-24 on the first day of the month, 25-48 on the second day of the month, etc.) If this is a multiple satellite product, the hour box number is adjusted by 1000 times the number of satellites which have data for the region.

S-9(2-3) - Whole Julian date (2 words):
This is the whole part of the Julian date. The multiple of 10 used to separate this value is 10000. (day) [2440000-2460000]

S-9(4) - Fractional Julian date:
This is the fractional part of the Julian date. [0-1.0]

S-9(5-8) - Scene fraction vector:
These values form a normalized vector giving the distribution of clear, partly cloudy, mostly cloudy, and overcast pixels inverted for this hour box. [0-1.0]

S-9(9-12) - α vector:
These are the albedos for clear, partly cloudy, mostly cloudy, or overcast scene types within this hour box.[0-1.0]

S-9(13) - $COS(ZEN)_{SUN}$:
This is the average cosine of the solar zenith angle in the range of 0 - 90 degrees for the pixels assigned to this hour box. $COS(ZEN)_{SUN}$ is defined as 0 for all zenith angles greater than 90 degrees. [0-1.0]

S-9(14) - Satellite zenith angle:
This is the average satellite viewing zenith angle for the pixels assigned to this hour box. (degrees) [0-180] NOTE: This value is meaningless for products derived from multiple satellites.

S-9(15) - Azimuth angle:
This is the average relative azimuth angle (0 in the forward scattering direction) for the pixels assigned to this hour box. (degrees) [0-360] NOTE: This value is meaningless for products derived from multiple satellites.

S-9(16) - SOLAR:
This is the solar incidence for this local solar hour box. (Wm^{-2})

S-9(17) - $\overline{M}_{SW}$:
This is the average SWF estimate for this local solar hour box. (Wm^{-2})

S-9(18) - $M_{MIN_{SW}}$:
This is the minimum SWF estimate for this local solar hour box. (Wm^{-2})

S-9(19) - $M_{MAX_{SW}}$:
This is the maximum SWF estimates for this local solar hour box. (Wm^{-2})

S-9(20) - σ_{SW}:
This is the standard deviation of SWF estimates for this local solar hour box. (Wm^{-2})

S-9(21) - N_{SW}:
This is the number of individual SWF estimates assigned to this local solar hour box.

S-9(22) - $\overline{M}_{LW}$:
This is the average LWF estimate assigned to this local solar hour box. (Wm^{-2})

S-9(23) - $M_{MIN_{LW}}$:
This is the minimum LWF estimate for this local solar hour box. (Wm^{-2})

S-9(24) - $M_{MAX_{LW}}$:
This is the maximum LWF estimate for this local solar hour box. (Wm^{-2})

S-9(25) - σ_{LW}:
This is the standard deviation of LWF estimates for this local solar hour box. (Wm^{-2})

S-9(26) - N_{LW}:
This is the number of individual LWF estimates assigned to this local solar hour box.

S-9(27-28) - $M_{DIFF_{SW}}, M_{DIFF_{LW}}$:
These values, used for processing multiple satellites only, are the maximum difference between individual mean SWFs or LWFs. For single satellite products, these values are zero. (Wm^{-2})

S-9(29-32) - $\sigma_{\alpha_{CS}}, \overline{M}_{LW_{CS}}, \sigma_{LW_{CS}}, N_{LW_{CS}}$:

$\sigma_{\alpha_{CS}}$: the standard deviation of the clear-sky albedo.

$\overline{M}_{LW_{CS}}$: the average clear-sky LWF estimate. (Wm^{-2})

$\sigma_{LW_{CS}}$ standard deviation of clear-sky LWF estimates. (Wm^{-2})

$N_{LW_{CS}}$: number of clear-sky LWF estimates.

S-10

Nonscanner Output Product (S-10) values are represented by Table 7. For each parameter listed below, the units are given in parentheses and the numbers in brackets identify the possible range.

Interpretation of S-10 record 1 quantities

S-10(1) - Region number

Numerical Filter (5.0 degree):
An integer from 1 to 2592 denotes one of the 5.0 x 5.0 degree ERBE regions. Region 1 lies in the range
85.0° <lat<=90° (0° <=colat< 5.0°), 0° <=long<5.0°. The regions are numbered consecutively, west to east, 72 per latitude band. The last row of regions includes a latitude of -90 degrees (colat=180 degrees).

Shape Factor (10.0 degree):
An integer from 1 to 648 denotes one of the 10.0 x 10.0 degree ERBE regions. Region 1 lies in the range
80.0° <lat<=90° (0° <=colat< 10.0°), 0° <=long<10.0°. The regions are numbered consecutively, west to east, 36 per latitude band. The last row of regions includes a latitude of 90 degrees (colat = 180 degrees).

S-10(2) - Geographic scene type:
The fraction denoting the cloud-free land + desert geotype. If greater than 0.5, the longwave model is applied.

S-10(3-11) - Scene fraction histogram:
These are the sum of all scene fractions for one month for clear, partly cloudy, mostly cloudy, and overcast scenes. The scene fraction histograms and scene fraction vectors have a dimension of nine. (See Table 8)

S-10(12-25) - Monthly (day) quantities:
These are monthly means based on daily calculations of flux. For longwave quantities, the daily means are obtained from the extrapolation, interpolation, and diurnal modeling algorithms that operate on the existing longwave estimates. The extrapolation and interpolation algorithms will, in general, cross daily boundaries, but the longwave diurnal model applied to land scenes operates on a specific day.

The shortwave quantities are based on calculations for specific days. The days are defined to be symmetric about solar noon.

$\overline{M}_{SW}$: the monthly mean SWF based on monthly mean albedo and the sum of integrated solar incidence over the entire month. (Wm^{-2})

$$\overline{M}_{SW} = \bar{\alpha} \cdot \sum_{d=1}^{N} S(d) / (24 \cdot N)$$

where N = all days of month.

- $M_{MIN_{SW}}$: minimum daily mean for days with at least one SWF estimate. (Wm^{-2})
- $M_{MAX_{SW}}$: maximum daily mean for days with at least one SWF estimate. (Wm^{-2})
- σ_{SW} standard deviation of daily means for days with at least one SWF estimate. (Wm^{-2})
- N_{SW}: the number of days with at least one SWF estimate. [1-31]

$\overline{M}_{LW}$: the monthly mean LWF based on all extrapolated, interpolated, and modeled LWF values for the month in this region. (Wm^{-2})

$$\overline{M}_{LW} = \sum_{d=1}^{N} \sum_{h=1}^{24} M_{LW}(d,h) / (24 \cdot N)$$

where N = all days of month. (Reference 4)

- $M_{MIN_{LW}}$: the minimum daily mean of the LWF for the month. (Wm^{-2})
- $M_{MAX_{LW}}$: the maximum daily mean for the LWF for the month. (Wm^{-2})
- σ_{LW} standard deviation for the LWF daily means for every day in the month. (Wm^{-2})
- N_{LW}: number of days with at least one LWF estimate. [1-31]

$\bar{\alpha}$: the monthly mean albedo from daily values, based on the sum of all integrated daily SWF is calculated for days with at least one SWF estimate. [0-1.0]

$$\bar{\alpha} = 24 \cdot \sum_{D_{SW}} M_{SW}(d) / \sum_{D_{SW}} S(d)$$

The solar incidence is integrated from sunrise to sunset for each day with SWF data, assuming a sun position for the day that is fixed at its position for $0^h 0^m 0^s$ UT. (Reference 4)

$\overline{M}_{NET}$: the monthly net flux defined from $\bar{\alpha}$, the sum of integrated solar incidence over the entire month, and monthly net LWF. (Wm^{-2})

$$\overline{M}_{NET} = \left[(1 - \bar{\alpha}) \cdot \sum_{d=1}^{N} S(d) / (24 \cdot N) \right] - M_{LW}$$

- TSOLRD (2 words): the monthly total integrated solar incidence for the entire month. The multiple of 10 used to separate this value is 1000. ($W\text{-}hm^{-2}$)

S-10(26-39) - Monthly (hour) quantities:
These are monthly means based on values averaged over the month at each local hour. In general, they result in different values for the same radiometric quantity compared to the monthly (day) means.

$\overline{M}_{SW}$: the monthly mean SWF based on the monthly mean albedo and the sum of integrated solar incidence over the entire month. (Wm^{-2})

$$\overline{M}_{SW} = \bar{\alpha} \cdot \sum_{d=1}^{N} S(d) / (24 \cdot N)$$

where N = all days of month.

- $M_{MIN_{sw}}$: the minimum monthly hourly mean SWF as calculated for days with at least one SWF estimate. It can be zero if there is at least one nighttime hour during the month. (Wm^{-2})

- $M_{MAX_{sw}}$: the maximum monthly hourly mean SWF as calculated for days with at least one SWF estimate. (Wm^{-2})

- σ_{SW} the standard deviation of all monthly (hour) mean SWF including nighttime values. This value may be a large number without much physical significance. (Wm^{-2})

- N_{SW}: the number of hours that had at least one SWF estimate during the month. [1-24]

$\overline{M}_{LW}$: the monthly mean LWF based on all extrapolated, interpolated, and modeled LWF values only for days during the month that had at least one actual LWF estimate. (Wm^{-2}) (Reference 4)

$$\overline{M}_{LW} = \sum_{h=1}^{24} M_{LW}(h)/24$$

- $M_{MIN_{LW}}$: the minimum LWF for days with at least one LWF estimate. (Wm^{-2})

- $M_{MAX_{LW}}$: the maximum LWF for days with at least one LWF estimate. (Wm^{-2})

- σ_{LW} the standard deviation of all monthly (hour) mean LWF for days with at least one LWF estimate. (Wm^{-2})

- N_{LW}: the number of hours that had at least one LWF estimate during the month. [1-24]

$\overline{\alpha}$: the monthly mean albedo from monthly hourly values, based on the sum of all SWF calculated for days with at least one SWF estimate.

$$\overline{\alpha} = 24 \cdot \sum_{D_{SW}} M_{SW}(d) / \sum_{D_{SW}} S(d)$$

where D_{sw} = days with at least one SWF measurement. (Reference 4)

There is no correction for integrated solar incidence in the monthly hourly albedo calculations. Since the albedo is in the form of a dimensionless ratio, the monthly (hour) albedo will generally be very close to the monthly (day) albedo. [0-1.0]

$\overline{M}_{NET}$: the monthly net flux defined from $\overline{\alpha}$, the sum of integrated solar incidence over the entire month, and monthly net LWF defined from days with at least one LWF estimate. (Wm^{-2})

$$\overline{M}_{NET} = \left[(1-\overline{\alpha}) \cdot \sum_{d=1}^{N} S(d)/(24 \cdot N)\right] - M_{LW}$$

- TSOLRH (2 words): the monthly total integrated solar incidence for the entire month. The multiple of 10 used to separate this value is 1000. ($W\text{-}hm^{-2}$)

S-10(40-473) - Daily quantities:
These are quantities calculated for each day in the month; i.e., there are 31 sets of values on the file. A set consists of the following values.

- DEO: the distance-corrected solar constant for the day. (Wm^{-2})

$\overline{M}_{SW}$: for each day with at least one SWF estimate, the sum of all estimates and modeled SWFs, divided by 24, and corrected by the ratio of integrated to summed solar incidence. This value is called the integrated SWF. (Wm^{-2})

$$\overline{M}_{SW}(d) = [S(d)/S'(d)] \cdot \sum_{h=1}^{24} M_{SW}(h)/24$$

where S(d) and S'(d) are the integrated and summed solar radiances, respectively. (Reference 4)

- $M_{MIN_{sw}}$: the minimum estimated or modeled SWF for the day. This value will be zero for days with at least one nighttime hour. (Wm^{-2})

- $M_{MAX_{sw}}$: the maximum estimated or modeled SWF for the day. (Wm^{-2})

- σ_{SW} the standard deviation of all modeled or estimated SWF values for the day. This may be a large number without much physical significance for days having at least one nighttime hour. (Wm^{-2})

- N_{SW}: the number of hours with SWF estimates for the day. [1-24]

$\overline{M}_{LW}$: daily LWF consisting of estimates and extrapolated, interpolated, and modeled values. (Wm^{-2}) If the half-sine fit was applied, all daily LWF quantities will contain fill values.

- $M_{MIN_{LW}}$: the minimum estimated or modeled LWF for the day. (Wm^{-2})
- $M_{MAX_{LW}}$: the maximum estimated or modeled LWF for the day. Wm^{-2})
- σ_{LW} the standard deviation of all modeled or estimated LWF for the day. (Wm^{-2})
- N_{LW}: the number of hours with LWF estimates for the day. [1-24]

$\bar{\alpha}$: the daily albedo defined as the ratio of integrated daily SWF to the integrated daily solar incidence. [0-1.0]

$$\bar{\alpha}(d) = \bar{M}_{sw}(d)/S(d)$$

where S(d) = integrated daily solar incidence. (Reference 4)

- SOLARD (2 words): integrated solar incidence over a day. The multiple of 10 used to separate this value is 1000. ($W\text{-}hm^{-2}$)

S-10(474-977) - Monthly hourly quantities:
These are calculated for the month at each local hour, i.e., there are 24 sets of values on the file. A set consists of the following values.

$\bar{M}_{sw}$: the monthly hourly mean SWF for this hour. (Wm^{-2})
- $M_{MIN_{SW}}$: the minimum estimated SWF for this hour. This value will be zero for nighttime hours. (Wm^{-2})
- $M_{MAX_{SW}}$: the maximum SWF for this hour. (Wm^{-2})
- σ_{SW} the standard deviation for SWF at this hour. (Wm^{-2})
- N_{SW}: the number of days with SWF estimates for the hour. [1-31]
- SUM_{SW} (2 words), $SUM2_{SW}$ (2 words): the sum and sum squared of actual SWF estimates at this hour. These values are intended for doing tests of statistical significance for diurnal variability. The multiple of 10 used to separate these values is 1000. ($W\text{-}hm^{-2}$), $((W\text{-}hm^{-2})^{-2})$

$\bar{M}_{LW}$: the monthly hourly average LWF for this hour. (Wm^{-2})
- $M_{MIN_{LW}}$: the minimum LWF for days with LWF estimates for this hour. (Wm^{-2})
- $M_{MAX_{LW}}$: the maximum LWF for days with LWF estimates for this hour. (Wm^{-2})

σ_{LW}: the standard deviation for LWFs for days with LWF estimates at the hour. (Wm^{-2})
- N_{LW}: the number of days with LWF estimates at the hour. [1-31]
- SUM_{LW} (2 words), $SUM2_{LW}$ (2 words): the sum and sum squared of actual LWF estimates at this hour. These values are intended for doing tests of statistical significance on diurnal variability. The multiple of 10 used to separate these values is 1000. ($W\text{-}hm^{-2}$), $((W\text{-}hm^{-2})^{-2})$

$\bar{\alpha}$: monthly hourly albedo defined as the ratio of monthly hourly SWF to the integrated solar incidence. [0-1.0]
- SOLARH (2 words): integrated solar incidence over those days with SWF data for a given hour. The multiple of 10 used to separate this value is 1000. ($W\text{-}hm^{-2}$)

S-10(978) - Number of Hour Boxes:
The total number of hours in the month with one or more estimates of any kind. Record 2 length is determined by $N_{HR\text{-}DAY}$ times 38.

S-10(979) - NOAA-9 Deadscanner Flag:
This is an integer with a value of zero or one. Zero indicates data from a month when the scanner was operating, or there is no NOAA-9 data in the data set. One indicates data from a month when the NOAA-9 scanner was not operating.

S-10(980) - ERBS Deadscanner Flag:
This is an integer with a value of zero or one. Zero indicates data from a month when the scanner was operating, or there is no ERBS data in the data set. One indicates that this is data from a month when the ERBS scanner was not operating.

S-10(981) - NOAA-10 Deadscanner Flag:
This is an integer with a value of zero or one. Zero indicates data from a month when the scanner was operating, or there is no NOAA-10 data in the data set. One indicates data from a month when the NOAA-10 scanner was not operating.

S-10(982) - Half-sine flag:
This is an integer with a value of zero or one. Zero indicates that the half-sine algorithm for longwave was not used. One indicates that the half-sine algorithm for longwave was used.

Interpretation of S-10 Record 2 Quantities

The Hourly/Day estimates constitute the individual estimates which are adjusted to the conditions at the local solar half hour with the aid of directional models appropriate to the scene types represented (See Table 9, and Table 10). The Hourly/Day statistics apply to the averaging procedures done by Monthly Time/Space Averaging. For example, $\overline{M}_{SW}$ applies not to a mean value, but to the result of a running average applied to nonscanner estimates in the same region and local solar hour box. The standard deviation applies as well to these (few) measurements.

S-10(1) - Hour box:
This is an integer from 1-744 designating the local solar hour box to which the estimate has been assigned. (Hours run from 1-24 on the first day of the month, 25-48 on the second day of the month, etc.). If this is a multiple satellite product, the hour box number is adjusted by 1000 times the number of satellites which have data for the region.

S-10(2-3) - Whole Julian date (2 words):
This is the whole part of the Julian date. The multiple of 10 used to separate this value is 10000. (day) [2440000-2460000]

S-10(4) - Fractional Julian date:
This is the fractional part of the Julian date. (day) [0-1]

S-10(5-13) - Scene fraction vector:
These values form a normalized vector giving the distribution of clear, partly cloudy, mostly cloudy, and overcast pixels inverted by the Inversion/DDB Subsystems for this hour box. [0-1.0]

S-10(14-22) - α vector:
These are the albedos for clear, partly cloudy, mostly cloudy, or overcast scene types within this hour box. [0-1.0]

S-10(23) - $COS(ZEN)_{SUN}$:
This is the average cosine of the solar zenith angle in the range of 0 - 90 degrees for the pixels, as a result of a running average applied in Monthly Time/Space Averaging. COS(ZEN) is defined as 0 for all zenith angles greater than 90 degrees. [0-1.0]

S-10(24) - Satellite zenith angle:
This is the average satellite-viewing zenith angle for the pixels. (degrees) [0-180]
NOTE: This value is meaningless for products derived from multiple satellites.

S-10(25) - Azimuth angle:
This is the average relative azimuth angle (0 in the forward scattering direction) for the pixels. (degrees) [0-360] NOTE: This value is meaningless for products derived from multiple satellites.

S-10(26) - SOLAR:
This is the solar incidence for the local solar hour box. (Wm^{-2})

S-10(27) - $\overline{M}_{SW}$:
This is the average SWF adjusted to the local solar hour box and averaged by Monthly Time/Space Averaging. (Wm^{-2})

S-10(28) - $M_{MIN_{SW}}$:
This is the minimum SWF estimate for the local solar hour box. (Wm^{-2})

S-10(29) - $M_{MAX_{SW}}$:
This is the maximum SWF estimate for the local solar hour box. (Wm^{-2})

S-10(30) - σ_{SW}:
This is the standard deviation of SWF estimates for the local solar hour box. (Wm^{-2})

S-10(31) - N_{SW}:
This is the number of individual SWF estimate records provided to the local solar hour box.

S-10(32) - $\overline{M}_{LW}$:
This is the average LWF estimate as averaged by Monthly Time/Space Averaging. (Wm^{-2})

S-10(33) - $M_{MIN_{LW}}$:
This is the minimum LWF estimate for the local solar hour box. (Wm^{-2})

S-10(34) - $M_{MAX_{LW}}$:
This is the maximum LWF estimate for the local solar hour box. (Wm^{-2})

S-10(35) - σ_{LW}:
This is the standard deviation of LWF estimates for the local solar hour box. (Wm^{-2})

S-10(36) - N_{LW}:
This is the number of individual LWF estimate records provided to the local solar hour box.

S-10(37-38) - $M_{DIFF_{SW}}$, $M_{DIFF_{LW}}$:
These values, used for processing multiple satellites only, are the maximum difference between individual mean SWF or LWF. For single satellite products, these values are zero. (Wm^{-2})

Unit of Measurement:

Units of measurement for the calculated and measured science variables for the S-9/S-10 data product can be found in the Variable Description/Definition Section of this document.

Data Source:

Please refer to the Summary of Parameters Section of this document.

Data Range:

Please refer to the Temporal Coverage Map Section of this document for the archival status of the ERBE S-9/S-10 product.

Sample Data Record:

ERBE data records are quite large (on the order of 104 or 105 binary bytes per record).Reproducing sample records of this size in a document of this sort is impractical.

8. Data Organization:

Data Granularity:

A general description of data granularity as it applies to the IMS appears in the EOSDIS Glossary.

The S-9 and S-10 data granules are the generated products of combining data from all functioning instruments. Each archived granule contains data, of a defined spatial resolution as described in Table 11, for one month.

Table 11: S-9 and S-10 Data Set Products for Data Month

Product	Data Sets	Data Filename*	Description of Data Sets
S-9	ERBE_S9_NAT	s9_yymm_s_a**	File 1 of scanner 2.5 deg. regional averages
		s9_yymm_s_b**	File 2 of scanner 2.5 deg. regional averages
		s9_yymm_s_c**	File 3 of scanner 2.5 deg. regional averages
		s9_yymm_s-h**	File 8 of scanner 2.5 deg. regional averags
S-10	ERBE_S10-MFOV_NF_NAT	s10_Mfov_nf_yymm_s	Nonscanner medium field-of-view numerical filter 5.0 deg. regional averages
	ERBE_S10-WFOV_NF_NAT	s10_wfov_nf_yymm_s	Nonscanner wide field-of-view numerical filter 5.0 deg. regional averages
	ERBE_S10-MFOV_SF_NAT	s10_mfov_sf_yymm_s	Nonscanner medium field-of-view shape factor 10.0 deg. regional averages
	ERBE_S10-WFOV_SF_NAT	s10_wfov_sf_yymm_s	Nonscanner wide field-of-view shape factor 10.0 deg. regional averages

** yy represents the year (e.g., 89 - 1989); mm represents the number value of a month (e.g., 01 = January, 12 = December)*

s represents the satellite code:
1 = NOAA-9
2 = ERBS
3 = NOAA-10

4 = NOAA-9/NOAA-10
5 = ERBS/NOAA-9
6 = ERBS/NOAA-10
7 = NOAA-9/ERBS/NOAA-10

*** a, b, . . .h indicate files 1 through 8 of the S-9 data for a month.*

Data Format:

The S-9 and S-10 products contain a header record, a scale factors record, and data records. The S-9 for one month consists of three to eight files and the S-10 for one month consists of one to four files. The products can be obtained on 9-track, 8mm, or 4mm tape media or electronically as disk files (i.e., a stream of bits) from the Langley ASDC. Read software is also provided. When a user is connected to the on-line Langley ASDC system, a particular data set pertaining to the type of ERBE S-9 or S-10 data of interest can be selected. Table 11 depicts the data sets produced each data month. Column one lists the type of S-9 or S-10 product, Column two lists the names of data sets which the user will see as he orders his data from the ASDC, Column three represents the names of the files of the data that the user will receive from the ASDC, and Column four gives a description of each data set.

The header record identifies the data and also serves as an identifying number for any correspondence between a user and the ERBE Data Management Team. It is a 30-byte record formatted as 8-bit bytes and defined in Table 12. An example of the information in this header for an S-9/S-10 is given in Table 13.

Table 12: Standard ERBE Header Record

Bytes	Description	Value	Interpretation
1-2	Subsystem Indicator	1-7	The subsystem outputting the data product is: 1 - Telemetry 2 - Ephemeris 3 - Attitude 4 - Merge/FOV/Count Conversion 5 - Inversion 6 - Daily Data Base and Monthly Time/Space Averaging 7 - Output Products
3-4	Product Code	1-99	Each subsystem assigns its output (tape, disc, paper, plot, etc.) a unique number for identification. See Table 1 in Data Products Catalog for individual subystem definitions.
5-6	Spacecraft Indicator	1-7	The data is from the following combination of spacecraft: 1 - NOAA-9 only 2 - ERBS only 3 - NOAA-10 only 4 - NOAA-9 and NOAA-10 5 - NOAA-9 and ERBS 6 - NOAA-10 and ERBS 7 - NOAA-9 and NOAA-10 and ERBS
7-8	Whole Julian date (high-order part)	e.g., 244	Leftmost 3 digits of the 7-digit whole part of the intiial Julian date.
9-10	Whole Julian date (low-order part)	e.g., 5700	Rightmost 4 digits of the 7-digit whole part of the initial Julian date.
11-12	Fractional Julian date	e.g., 5000	First 4 digits of the fractional part of the initial Julian date times 10000.
13-14	Processed Version Counter	1-99	A counter initially set to 1 and incremented by one each time the product is reprocessed.
15-16	Year Processed	e.g., 84	The last two digits of the year of process date. The process date is

			the date (local time) when the data product was processed (or reprocessed) at Langley Research Center, Hampton, VA.
17-18	Month Processed	1-12	Month of the process date. January is 1 and December is 12.
19-20	Day Processed	1-31	Day of the process date.
21-22	Hour Processed	0-23	Hour of the process date.
23-24	Minute Processed	0-59	Minute of the process date.
25-25	Second Processed	0-59	Second of the process date.
27-30	Spares	0	Zero-filled spares to produce a record which is multiple of 8-, 16-, and 60- bits.

Table 13: Example of S-10N Header Record

Bytes	Description	Example	Note
1-2	Subsystem Indicator	6	The S-9 or S-10 is output from the Monthly Time/Space Averaging Subsystem and will always have a 6 as the subsystem indicator.
3-4	Product Code	60, 62, 64, 66, 68, 82, 84, 86, 88	The Monthly Time/Sapce Averaging Subsystem has defined the product codes as follows: 60: S-9 scanner 62, 82: S-10, S-10N numerical filter MFOV* 64, 84: S-10, S-10N numerical filter WFOV* 66, 86: S-10, S-10N shape factor MFOV* 68, 88: S-10, S-10N shape factor WFOV*
5-6	Spacecraft Indicator	2	A number 1-7 will appear here depending on whether data is for a single satellite or a combination of satellites.
7-8	Whole Julian date (high-order part)	244	The initial Julian date for this example is 6005.5.
9-10	Whole Julian date (low-order part)	6005	The whole Julian date for the first day of the month of actual data.
11-12	Fractional Julian date	5000	The fractional Julian date will be 0.5.
13-14	Processed Version Counter	1	A value of 1 means that the product has been processed one time and not reprocessed.
15-16	Year Processed	84	For this example, the product was processed on February 3, 1984 at 9 P.M. $48^{M}54^{S}$.
17-18	Month Processed	2	
19-20	Day Processed	3	
21-22	Hour Processed	21	
23-24	Minute Processed	48	
25-25	Second Processed	54	
27-30	Spares	0	
** After all ERBE scanners were inoperative, nonscanner data were processed with an algorithm known as the "Time/Space Averaging Deadscanner Option" (see Section 9.3.1). Product codes 82, 84, 86, and 88 indicate S-10N data processed using this algorithm.*			

Following the header record are the scale factors which are used to pack the data. The record is written in 16-bit words. The first 67 values of

this record are used to pack Record Type 1. The next 38 values are used to pack Record Type 2. The correspondence of the scale factors to the data values is discussed in the Parameter/Variable Section of this document. They are used to unscale the integer data quantities as follows:
Real Quantity = (Integer Scaled Quantity From Type) / (Scale Factor)

9. Data Manipulations:

Formulae:

Derivation Techniques and Algorithms:

There are a number of steps in the processing of the ERBE data. The mathematics involved in each of these steps is beyond the scope of this document. However, interested readers are referred to the following: Suttles (reference 14), and Smith (reference 23).

Data Processing Sequence:

Processing Steps:

The Langley Research Center (LaRC) has the responsibility of processing and validating all science data from the ERBE mission and of distributing the resulting data products to the science community. The ERBE data processing system at LaRC uses a modular software subsystems approach to process the ERBE data, starting with the input telemetry and ephemeris data from Goddard Space Flight Center (GSFC) and NOAA and ending with the production of the required science data products.

The diagram in the Flowchart Figure shows the major steps in the science data processing, together with the primary input and output data products. The first step in this processing procedure is to ingest 24 hours of telemetry data from the ERBS, NOAA-9, or NOAA-10 spacecraft into the front-end processing subsystem of the Data Processing System. The processing at this step accounts for spacecraft differences and for differences in the data acquisition and handling systems of the ERBS and TIROS N satellites. The data are organized into a format that is common to data from GSFC and NOAA. Extensive data quality editing and evaluation are performed, including the checking of quality flags appended by the tracking networks and processing systems at GSFC and NOAA. The operational status of the instruments is determined, and all instrument housekeeping data and selected spacecraft housekeeping measurements are converted to engineering units and edited. Pointing vectors for the optical axes of the detectors are calculated in a local horizon coordinate system at the spacecraft.

The 8-day ephemeris data sets are processed and validated separately before combining them with the corresponding telemetry data. Orbital data are tested for consistency with data from the previous week, and tests are performed to verify the consistency of the orbit calculations between 1-minute data points. The tests include checks for in-plane and out-of-plane consistency and precision. The routine verification processing and other analyses performed to verify the accuracy of the ephemeris data have generally demonstrated accurate orbit determination for both the ERBS and NOAA spacecraft.

The next major processing stage begins with the merging of the output data from telemetry processing with data output from the ephemeris processing. The FOV locations on a surface at the TOA are determined for every radiometric measurement. The FOV locations are more critical for the scanner measurements than those of the nonscanner because of the small FOV of the scanner instrument. A FOV accuracy analysis has shown that the calculated locations of the scanner measurements are well within the FOV footprint of the instrument on the Earth.

At this processing stage, the raw measurements for each radiometric detector are also converted to incident radiances at the spacecraft. The conversion algorithms employ calibration coefficients that are based primarily on ground-based calibration data, but which are updated with results from in-flight calibrations.

In the inversion processing stage, data from the scanner detectors are used to identify the type of scene or source at the TOA that produced the raw radiometric measurements. Based on the scene type and geographical location, the scanner measurements are adjusted to account for changes in the spectral response in each detector. Using the selected scene-type, one of several angular directional models is selected for inverting or reducing the measurements from satellite altitude to radiant fluxes at the TOA. The nonscanner measurements are inverted using scene information determined during scanner data processing and two different inversion algorithms. One algorithm employs geometric shape factors and the other employs numerical filtering. An archival product, called the Processed Archival Tape (PAT), is produced at this point to retain detailed time histories of estimates of the radiant fluxes at the TOA.

The time-ordered estimates of TOA fluxes are sorted into spatial sequences for both the scanner and nonscanner measurements, grouping all estimates for a month together on a regional basis. A full calendar month of estimates is then retrieved for each region of the Earth. Hourly, daily, and monthly estimates of several different parameters are derived by interpolation using directional models that describe the temporal variation of the radiation budget components. Archival products of monthly averages of radiation components for both the scanner and nonscanner are produced at this point.

Several archival products are produced at the final stage of data processing. The nested averages product gives values of the scanner and nonscanner fluxes from each instrument averaged over various spatial scales. The processing at this stage also combines data from all available spacecraft to produce a combined-satellite product of TOA fluxes averaged over the same spatial scales. An archival product for solar monitor measurements is also produced to provide time histories of solar calibration data. Finally, a scene validation product is produced that combines ERBE data with measurements from the AVHRR and the HIRS instruments. Data from these two NOAA instruments are used to validate the scene identification algorithm. Currently all archival data products are distributed first to the ERBE Science Team for review and validation and then to LaRC ASDC for archival.

Processing Changes:

Processing changes are addressed in the Special Corrections/adjustments Section directly below.

Calculations:

Special Corrections/Adjustments:

Since the publication of Reference 4, several modifications have been made to Monthly Time/Space Averaging Algorithms which affected the S-9 and S-10 product in the following areas:

1. Monthly Shortwave Averages

   Monthly shortwave averages are calculated using the monthly mean albedo and the sum of the integrated daily solar incidence of all days (N) of the month:

   $$\overline{M}_{SW} = \overline{\alpha} \cdot \sum_{d=1}^{N} S(d) / (24 \cdot N) \quad (6)$$

   ($\overline{\alpha}$, and S(d) are defined in Reference 4)

2. Monthly Average Values

   An alternate definition of monthly average values may be expressed in terms of monthly hourly averages. In this case, calculate the average for each of the 24 local hours using only the days with measurements and then take the mean of the local hour averages. The calculation of the monthly hourly average albedo and SWF are the same as Equation 12 (Reference 4) and Equation 6 respectively, whether one first sums through the days or the hours of the month. Obviously, shortwave interpolation cannot take place on a given day if there are no shortwave measurements for that day.

3. Monthly Net Values

   In general, $\overline{M}_{NET}(mha)$ is not equal to $\overline{M}_{NET}$ as defined by Equations 18 and 13 (Reference 4) respectively, differing by the usage of the longwave interpolated values on days for which there were no longwave measurements. This difference can be significant if several days of measurements are missing. If there are no shortwave measurements for a given month and the monthly total integrated solar incidence is greater than zero, the solar and net parameters of these regions are not used in the global averages. Some of these regions lie on the latitude belt where the solar terminator occurs with the seasonal movement of the solar declination. Naturally, if the monthly total integrated solar incidence equals zero, the shortwave portion of Equations 18 and 13 (Reference 4) is zero. The sampling problems outlined in this paragraph will ultimately have to be dealt with outside the context of ERBE operational software.

4. Clear-sky Longwave Flux

   The shortwave parameters of the monthly clear-sky averages are the same as the monthly averages, except that clear-sky measurements are used. The same holds true for the longwave parameters for ocean, snow, and coast geotypes. Over land and desert geotypes, however, the lack of clear-sky longwave measurements on a daily basis or even on a monthly time-scale as in tropical convective regions, discourage any type of daily modeling. Therefore, a half-sine model is best applied after the clear-sky longwave measurements have been sorted by local hour. This will better account for the clear-sky diurnal variation, assuming that the clear-sky longwave diurnal range exceeds the day-to-day fluctuations for a given local hour. This way, the bias toward either daytime or night time clear-sky measurements have been reduced. First, the monthly hourly LWF MLW(h) as defined by Equation 16 (Reference 4) is calculated, but only clear-sky longwave measurements are used. The same conditions as defined by the LW half-sine model section apply, except that the least squares fit is weighted by the number of measurements for the local hour, and the night time average is the mean of all night time clear-sky longwave measurements. This method is used for both the monthly daily and monthly hourly clear-sky longwave averages for land and desert regions.

   An additional change was made to the clear-sky averaging algorithm that corrects the misclassification of nighttime clear pixels as partly cloudy. For each nighttime hour box over land regions, a new clear-sky percentage is estimated by assuming that 100f the pixels classified as clear and partly cloudy are actually clear. If this new clear percentage exceeds 5 and represents an increase over the original clear-sky percentage, then the clear-sky longwave flux is recalculated using the mean and standard deviation of the total longwave flux.

5. Normalized Directional Models (See Table 8)

   Some of the directional models have been altered since the publication of Reference 4.

6. ERBE Directional Albedo Models (See Table 9)

   Some of the directional albedo models have been improved since the publication of Reference 4.

7. ERBE Scene Types (See Table 10)

8. ERBE Albedo Directional Models for Ocean Scenes

9. ERBE Albedo Directional Models for Land Scenes

10. ERBE Albedo Directional Models for Clear Over Snow and Clear Over Desert Scenes

11. Region-Specific Directional Model for the Deadscanner Option

12. Half-sine Model for Nonscanner Longwave Flux

    In nonscanner data, in some land regions like deserts and arid mountains, longwave flux exhibits a pronounced diurnal variation. A single diurnal fit to the monthly ensemble of all longwave data points based on a half-sine curve has been added to the nonscanner algorithm. Rather than daily fits, a fit is performed on monthly hourly averages. Given this month of data, there are five criteria which are applied to determine whether or not a good fit can be obtained:

    1. Must have at least 1 daytime measurement located more than 1 hour from the terminator
    2. Must have at least 1 nighttime measurement
    3. A least squares sinewave fit to the daytime data must have a positive amplitude
    4. The peak value of the daytime fit must not exceed 400 Wm^{-2}
    5. The length of the day must exceed 2 hours

    If any of these criteria are not met, the fit will not be performed and the already calculated averages will be retained.

    The daytime curve is a least squares sine fit weighted by the number of measurements at each local hour. The nighttime data are simply averaged and the constant value is used for all night hours. These monthly hourly values for day and night are then stored. The resulting averages of longwave are stored in the arrays formerly used for the Monthly Hourly Longwave Average. The Daily Longwave Average values are replaced with the Monthly Hourly Longwave average values over land and deserts, if a fit is made. These Daily Longwave Average values over land are then used to calculate net radiation for the land regions. The algorithm and data products for other scene types are unchanged.

    A flag to indicate whether the half-sine fit was used in a given region was added to the first data record for each region.

13. Maxima and Minima

    The monthly hourly averaged results and the corresponding statistics (minima, maxima, standard deviations) are a combination of measurements and models. The maximum and minimum values for the monthly hourly parameters should be handled with caution because they include extrapolation or interpolation between measurements having many missing hours of data.

Calculated Variables:

Please refer to the Variable Description/Definition Section of this document.

Graphs and Plots:

There are no graphs or plots available for the S-9/S-10 products.

10. Errors:

Sources of Error:

A discussion of various factors that may lead to errors are discussed in the Confidence Level/Accuracy Judgement Section of this document.

Quality Assessment:

Data Validation by Source:

The measurement of radiation budget requires a massive data processing system. ERBE's system uses about 250,000 lines of FORTRAN code. This system also uses an additional 150,000 lines of off-line diagnostic work. The stringent requirements for accuracy in the budget dictate an acute attention to detail.

The ERBE data processing system uses about 25,000 coefficients. These coefficients are conveniently arranged in three groups. The first group is the set of "calibration coefficients" that appear in the algorithms converting telemetry counts to instrument irradiation. Ground- and in-flight-calibration sources provided these coefficients. The second group includes the angular distribution models (ADMs) and spectral unfiltering coefficients needed for inversion. A categorization of the Nimbus-7 ERB measurements forms the base for the ADM's. Missing bins were filled using the reciprocity principle. A combination of radiative transfer results and measurements of the instrument spectral responses provides the spectral correction coefficients. The third and final group of parameters consists of the coefficients needed for time averaging, mainly the directional models. These models describe the dependence of each scene type's albedo upon solar zenith angle. These directional models also came from the Nimbus-7 ERB, but have been suitably supplemented by Geostationary Operational Environmental Satellite (GOES) observations where needed. The majority of the coefficients are used in the inversion process.

The earth's radiation budget is not easy to measure, even indirectly. The ERBE Science Team has relied on consistency and measurement intercomparisons for validation. Fortunately, ERBE data provides a number of these checks. These criteria provide a way of judging the consistency of the various parameters in the data processing system.

Confidence Level/Accuracy Judgement:

The ERBE data products are complex assemblages of data and models. Thus, their uncertainties are difficult to compute. The following numbers represent estimates of the standard deviations about a given datapoint within which the true measurement might lie. They are not definitive confidence intervals, but are intuitively based on the observed discrepancies in the intercomparisons. It is also important to remember that different measurements have different uncertainties. First, for instantaneous radiances, we expect uncertainties of about 10f longwave observations of filtered radiance and 2 0.000000or shortwave. Radiative transfer comparison and spectral consistency provide the basis for this uncertainty estimate. Second, on an instantaneous observation of flux from 2.5 X 2.5 degree geographic regions, the ERBS/NOAA-9 intercomparisons offer reasonable estimates of uncertainty. These are 5 Wm^{-2} in the longwave and 15 Wm^{-2} in the shortwave. Third, on a monthly average, regional basis, the uncertainties in the scanner data are about 5 Wm^{-2} for shortwave and 5 Wm^{-2} for longwave. These come from simulations with GOES data. This uncertainty represents no change from the preflight estimate. The nonscanner averages may be somewhat more uncertain because of sampling and diurnal averaging process. Fourth, the uncertainty in global, annual average net radiation is probably about 5 Wm^{-2}. This estimate is based on the imbalance obtained using scanner data from the four validation months (April, July, and October 1985; January 1986).

Measurement Error for Parameters:

A discussion of measurement error is found in the Confidence Level/Accuracy Judgement Section of this document.

Additional Quality Assessments:

None.

Data Verification by Data Center:

The data were received on 12 inch worm media. Before the data were archived, the ASDC checked all granules to ensure that the size of the granules matched that which was delivered on the media. The version number of the granules was also checked so that the most current version of the data is available to the user community. Granule level metadata were extracted from the granules such as the product ID, satellite(s) ID, and data date.

11. Notes:

Limitations of the Data:

There are no known limitations or unreliable aspects in the algorithms implemented to generate the ERBE science data.

Known Problems with the Data:

There are no known problems or inconsistencies in the ERBE data.

Usage Guidance:

S-9:
The monthly hourly averaged results and the corresponding statistics (minimums, maximums, standard deviations) are a combination of measurements and models. The mean and standard deviation of these results, which are on the S-9, represent the best estimate of the monthly hourly results. However, the maximum and minimum values for the monthly hourly parameters should be handled with caution because they include the extrapolation or interpolation between measurements having many missing hours of data. Also note that one should not just average the measurements alone to determine the monthly hourly means, because it will give a misleading diurnal cycle. The combination of measurements and models gives a more reasonable estimate when compared to full-time sampling of the GOES.

S-10:
The monthly hourly averaged results and the corresponding statistics (minimums, maximums, standard deviations) are a combination of measurements and models. The mean and standard deviation of these results, which are on the S-10, represent the best estimate of the monthly hourly results. However, the maximum and minimum values for the monthly hourly parameters should be handled with caution because they include the extrapolation or interpolation between measurements having many missing hours of data. Also note that one should

not just average the measurements alone to determine the monthly hourly means, because it will give a misleading diurnal cycle. The combination of measurements and models gives a more reasonable estimate when compared to full-time sampling of the GOES.

Any Other Relevant Information about the Study:

Flux values and standard deviation values may contain a fill value (2^15 - 1). If a fill value was found during packing, the scale factor was not applied. A test for the presence of a fill value in any flux value should be made before the scale factor is applied. Also, when shortwave data are not available for calculation of albedos, these albedo values are set to zero in the S-9 and S-10 products.

12. Application of the Data Set:

Measurements of the radiation budget provide one of the important tools for the validation of numerical models of the atmosphere. They also provide possibilities for "climate experiments" by allowing the sensitivity of the radiation budget to various forcings to be studied empirically.

The use of cloud discrimination has provided a significant new source of information on the influence of clouds and the characteristics of clear-sky fluxes. This information is particularly important in understanding cloud forcing. It is also important in describing the response of clouds to climate change: the climate cloud sensitivity.

13. Future Modifications and Plans:

The ERBE project plans to complete the reprocessing, which is currently in progress, of the nonscanner data using inversion and time/space averaging processes which do not use scanner scene identification information.

Current plans are to reprocess the ERBE scanner data beginning in 1996 using the CERES algorithms.

To continue the measurements of the radiation budget, a second project,the Clouds and the Earth's Radiant Energy System (CERES), is currently being developed. CERES is a key component of the Earth Observing System (EOS). The CERES instruments are improved models of the Earth Radiation Budget Experiment (ERBE) scanner instruments. The strategy of flying instruments on Sun-synchronous, polar orbiting satellites, such as NOAA-9 and NOAA-10, simultaneously with instruments on satellites that have precessing orbits in lower inclinations, such as ERBS, was successfully developed in ERBE to reduce time sampling errors. CERES will continue that strategy by flying instruments on the polar orbiting EOS platforms simultaneously with an instrument on the Tropical Rainfall Measuring Mission (TRMM) spacecraft, which has an orbital inclination of 35 degrees. In addition, to reduce the uncertainty in data interpretation and to improve the consistency between the cloud parameters and the radiation fields, CERES will include cloud imager data and other atmospheric parameters. The first CERES instrument is scheduled to be launched on the TRMM spacecraft in 1997. Additional CERES instruments will fly on the EOS-AM platforms, the first of which is scheduled for launch in 1998, and on the EOS-PM platforms, the first of which is scheduled for launch in 2000.

14. Software:

Software Description:

Sample read software is available. The FORTRAN 77 program is able to read both the S-9 and S-10 products. Information on how to execute this program is also available.

Software Access:

The sample read software can be ordered through the Langley ASDC IMS or by contacting the Langley ASDC User and Data Services Office. (See below)

15. Data Access:

Contact Information:

Langley ASDC User and Data Services Office
NASA Langley Research Center
Mail Stop 157D
Hampton, Virginia 23681-2199
USA
Telephone: (757) 864-8656
FAX: (757) 864-8807

E-mail: support-asdc@earthdata.nasa.gov

Data Center Identification:

Langley ASDC User and Data Services Office
NASA Langley Research Center
Mail Stop 157D
Hampton, Virginia 23681-2199
USA
Telephone: (757) 864-8656
FAX: (757) 864-8807
E-mail: support-asdc@earthdata.nasa.gov

Procedures for Obtaining Data:

Data, programs for reading the data, and user's guides can be obtained through the EOSDIS Langley ASDC on-line system which will allow users to search through the data inventory and place orders on-line.

Langley ASDC User and Data Services Office
NASA Langley Research Center
Mail Stop 157D
Hampton, Virginia 23681-2199
USA
Telephone: (757) 864-8656
FAX: (757) 864-8807
E-mail: support-asdc@earthdata.nasa.gov
URL: http://eosweb.larc.nasa.gov

The Langley ASDC User and Data Services staff provides technical and operational support for users ordering data.

Data Center Status/Plans:

On a regular basis, individual ERBE data granules are reviewed by local members of the ERBE Science Team. Upon Science Team approval, the ERBE Data Management Team releases the data granule to the LaRC ASDC for archive.

16. Output Products and Availability:

No additional output products are available for the ERBE S-9/S-10 data sets.

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18. Glossary of Terms:

EOSDIS Glossary.

Albedo
: The ratio of shortwave radiant flux to the integrated solar incidence, where zero (0.0) represents total absorption, and one (1.0) represents total reflectance.

Level 2
: Level 2 is a data product level referring to retrieved environmental variables (e.g., ocean wave height, soil moisture, ice concentration).

Nadir
: That point on the celestial sphere vertically below the observer, or 180 degree from the zenith.

Radiance
: The radiant flux per unit solid angle per unit of projected area of the source; usual unit is the watt per square meter per steradian. Also known as steradiancy.

Radiant Flux
: The time rate of flow of radiant energy.

S-4: Regional, Zonal, and Global Averages Product
: The S-4 contains averages of flux and albedo on regional, zonal, and global scales for both scanner and nonscanner data. For more information on this product please refer to the ERBE S-4 Data Set Document.

S-4N: Regional, Zonal, and Global Averages Product
: The S-4N contains averages of flux and albedo on regional, zonal, and global scales for both scanner and nonscanner data. For more information on this product please refer to the ERBE S-4N Data Set Document.

S-4G: Regional, Zonal, and Global Gridded Averages Product
: The S-4G contains averages of flux and albedo on regional, zonal, and global scales for both scanner and nonscanner data. The S-4G product is arranged by parameter value. For more information on this product please refer to the ERBE S-4GN Data Set Document.

S-4GN: Regional, Zonal, and Global Gridded Averages Product
: The S-4GN contains averages of flux and albedo on regional, zonal, and global scales for nonscanner data. The S-4GN product is arranged by parameter value. For more information on this product please refer to the ERBE S-4G Data Set Document.

S-7: Medium-Wide Field-of-View Data Tape
: The S-7 product contains a condensed version of the nonscanner data that are found in a monthly set of the S-8 product, **except** that the shortwave estimates of the radiant flux at the top-of-atmosphere (TOA) are based on the mostly-cloudy over ocean bidirectional model. The S-7 product then provides a consistent data set of nonscanner TOA estimates which are not dependent on scene type and, therefore, not dependent on the operational status of the ERBE scanner instruments.

S-8: Processed Archival Tape
: The S-8 contains ERBE scanner and nonscanner radiometric measurements for one day and one satellite. Estimates of the flux at the TOA based on these measurements are also included.

S-9: Earth Radiant Fluxes and Albedo for Month (Scanner)
: The S-9 contains regional hourly and daily monthly averages as well as the actual individual hour box data which is the input data to the Monthly Time/Space Averaging Subsystem.

S-10: Earth Radiant Fluxes and Albedo for Month (Nonscanner)
: The S-10 contains regional hourly and daily monthly averages as well as the actual individual hour box data which are the input data to the Monthly Time/Space Averaging Subsystem. The S-10 contains numerical filter data of 5-degree resolution and shape factor data of 10-degree resolution from the nonscanner instrument.

S-10N: Earth Radiant Fluxes and Albedo for Month (Nonscanner)
: The S-10N product contains the same science information arranged in the same order as the S-10; however, there are some differences in the processing algorithms and data format. The data set S-10N consists of nonscanner data processed without scene identification from the scanner and with numerical filter cross-track enhancement technique. For more information on this product please refer to the ERBE S-10N Data Set Document.

Solar Incidence
: The total energy per unit area impinging on the Earth from the sun.

TSI: Total Solar Irradiance from the ERBS Satellite
: The TSI product contains total solar irradiance data that were collected every two weeks from the solar monitor. Each granule consists of six months of data and is in ASCII format.

Zenith
: That point on the celestial sphere vertically above the observer.

19. List of Acronyms:

EOSDIS Acronyms.

ADM - Angular Distribution Model
ASDC - Atmospheric Science Data Center
AVHRR - Advanced Very High Resolution Radiometer
ASCII - American Standard Code for Information Interchange
CERES - Clouds and Earth's Radiant Energy System
DAAC - Distributed Active Archive Center
DBMS - Database Management System
EOSDIS - Earth Observing System Data and Information System
ERB - Earth Radiation Budget
ERBE - Earth Radiation Budget Experiment
ERBS - Earth Radiation Budget Satellite
FOV - Field-of-View
GOES - Geostationary Operational Environmental Satellite
GSFC - Goddard Space Flight Center
HDF - Hierarchical Data Format
HIRS - High-Resolution Infrared Radiometer Sounder
IBB - Internal Blackbody
IPTS-68 - International Pressure and Temperature Standard of 1968
IMS - Information Management System
LaRC - Langley Research Center
LW - Longwave
LWF - Longwave Flux

MFOV - Medium Field-of-View
MRBB - Master Reference Blackbody
NASA - National Aeronautics and Space Administration
NCSA - National Center for Supercomputing Applications
NESDIS - National Environmental Satellite Data and Information Service
NFOV - Narrow Field-of-View
NOAA - National Oceanic and Atmospheric Administration
NOAA-9 - National Oceanic and Atmospheric Administration Operational Weather Monitoring Satellite number 9
NOAA-10 - National Oceanic and Atmospheric Administration Operational Weather Monitoring Satellite number 10
NORAD - North American Aerospace Defense Command
PAT - Processed Archival Tape
POCC - Payload Operation and Control Center
RAT - Raw Archival Tape
SAGE II - Stratospheric Aerosol and Gas Experiment II
SOCC - Satellite Operations and Control Center (NOAA)
SW - Shortwave
SWF - Shortwave Flux
SWICS - Shortwave Internal Calibration Source
TDRSS - Tracking and Data Relay Satellite System
TIROS - Television Infrared Radiometer Orbiting Satellite
TOA - Top-of-Atmosphere
TOT - Total (as in total channel)
URL - Uniform Resource Locator
UT - Universal Time
WFOV - Wide Field-of-View
WRR - World Radiation Reference

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